University of Nevada

Reno

Relationship of Basin Characteristics to Selected Water Chemistry Parameters in Upper Carson River Basin

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geological Engineering

by

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ABSTRACT

A study was conducted for screening the hydrologic-chemical characteristics which control the parameters of a basic flow-concentration equation. Sub-basin characteristics of geomorphology, geology, soils, and land use for fifteen sites in the Upper Carson River basin were quantified and related to flow-concentration parameters and ionic ratios of selected inorganic aqueous chemical components. Twenty-nine equations were developed, by use of a multiple regression computer program, which indicated relationships between basin characteristics and flow-concentration parameters. Influential characteristics for Carson sub-basins were compared to those delineated for Truckee sub-basins to determine the tranferability of results.

Findings indicate that characteristics controlling drainage rates are important in influencing the flow-concentration parameters and ionic ratios. Comparison of Truckee and Carson characteristics indicate similar hydrologic-chemical controls are at work in both basins although highly correlated generated multiple regression equations were poor predictors of actual values. This may be caused by the small number of basins studied. Extension of this approach to other river sub-basins will be made easier by results of this study.

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INTRODUCTION

Scope and Objectives

This study is an attempt to use methods employed by Bateman (in preparation, 1974) in the delineation of sub-basin characteristics (geomorphic, geologic, soils and land use) which influence intercept and slope parameters of a basic flow concentration equation, and also ionic rations, for fifteen sub-basins in Upper Carson River Basin (Table 1).

This study has three objectives. First, development of multiple regression equations relating intercept, slope, and ionic ratios separately to physiographic basin characteristics. These equations are then interpreted as to the relation of influential basin characteristics to the selected variables under study in order to attain a better insight irto hydrologic-chemical controls on water chemistry. Second, predictive capabilities are examined to determine the feasibility or applicability of using the development multiple regression equations for specific cases. Finally, comparisons of similarities between influential Carson River and influential Truckee River sub-basin characteristics is made to determine not only the transferability of methods used by Bateman but also to help determine if similar hydrologic-chemical controls are at work in both areas. (Note the terms basins and sub-basins are used interchangeably to refer to the watersheds under study.)

TABLE 1

Upper Carson Sub-basins Investigated in this Study:

1) Mott Canyon Creek
2) Fredericksburg Canyon Creek
3) Deep Canyon Creek
4) Horsethief Canyon Creek
5) Willow Creek
6) Red Lakes Creek
7) West Fork Carson River above Red Lakes Creek
8) Hot Springs Creek above Grovers Hot Springs
9) Spratt Creek
10) Pleasant Valley Creek
11) Indian Creek at Hangmans Bridge
12) Silver Creek
13) Wolf Creek
14) East Fork Carson River above Silver King Creek
15) Silver King Creek

PREVIOUS STUDIES

The use of physiographic characteristics in delineating hydrologic or chemical behavior of a watershed is now new. Anderson (1957) for sediment production in a basin, Gray (1962) for hydrograph synthesis, Pionke and Nicks (1970) with stream's salinity and, recently, Brown (1972) with nitrogen and phosphorus production from watersheds have all delineated the significant basin characteristics which influence selected hydrologic or chemical behavior. This concept can be extended to other hydrological-chemical relations. The basic dilution equation,

$$C = KQ^{-n} \tag{1}$$

where

C = concentration (mg/l)

Q = flow (CfS)

K and n are regression parameters

K = intercept of regression line

n = slope of regression line

and its permutations have been used by researchers in predictive endeavors. The basic equation has been shown to be far from perfect in its predictive capabilities because errors arise from the values of regression parameters K and n and time variant water chemistry. Ledbetter and Gloyna (1964) show that for selected rivers in the Southwest, n varies exponentially with flow and antecedent moisture conditions. Westphal (1973) in his study on the Truckee River, has suggested that K and n are subject to hydraulic controls on the stream channel. This implies that K and n may also be related to other characteristics of the basin besides flow, antecedent moisture, or streambed controls. Following this approach, Bateman (1974, in preparation) has analyzed 24 tributary basins in the Truckee River drainage to determine what other basin characteristics influence parameters K and n. The study presented herein is an extension of methods utilized by Bateman to another river system in the region.

STUDY AREA

Location

Fourteen of fifteen sub-basins studied are situated on the east slope of the Carson Range of the Sierra Nevada Mountains in Alpine County, California. Only one basin, Mott Canyon Creek, lies in Nevada. (See Location Map) Most sub-basins are tributary to either the West Fork or East Fork of the Carson River. Only two, Mott Canyon Creek and Fredericksburg Canyon Creek, are totally diverted for agricultural use.

Physiography

Topographically the east side of the Sierras is quite precipitous with peaks attaining heights of over 10,000 feet with up to 6,000 feet of relief above the valley floors. The area is cool year-round because of these high elevations, with average mean air temperatures ranging from a high of 87° F to a low of 22° F. Total annual precipitation, as measured at Woodfords, averages approximately 20 inches. Flora in the area is characterized by several types of conifer, predominately Jeffrey Pine (Pinus jeffreyi) and several species of fir. Sagebrush is a common shrub in the area.

Cretaceous granitic intrusives, commonly granodiorites, and Plicocene volcanics, almost entirely andesite flows dominate the geologic setting. Both units are cut by numerous normal faults,

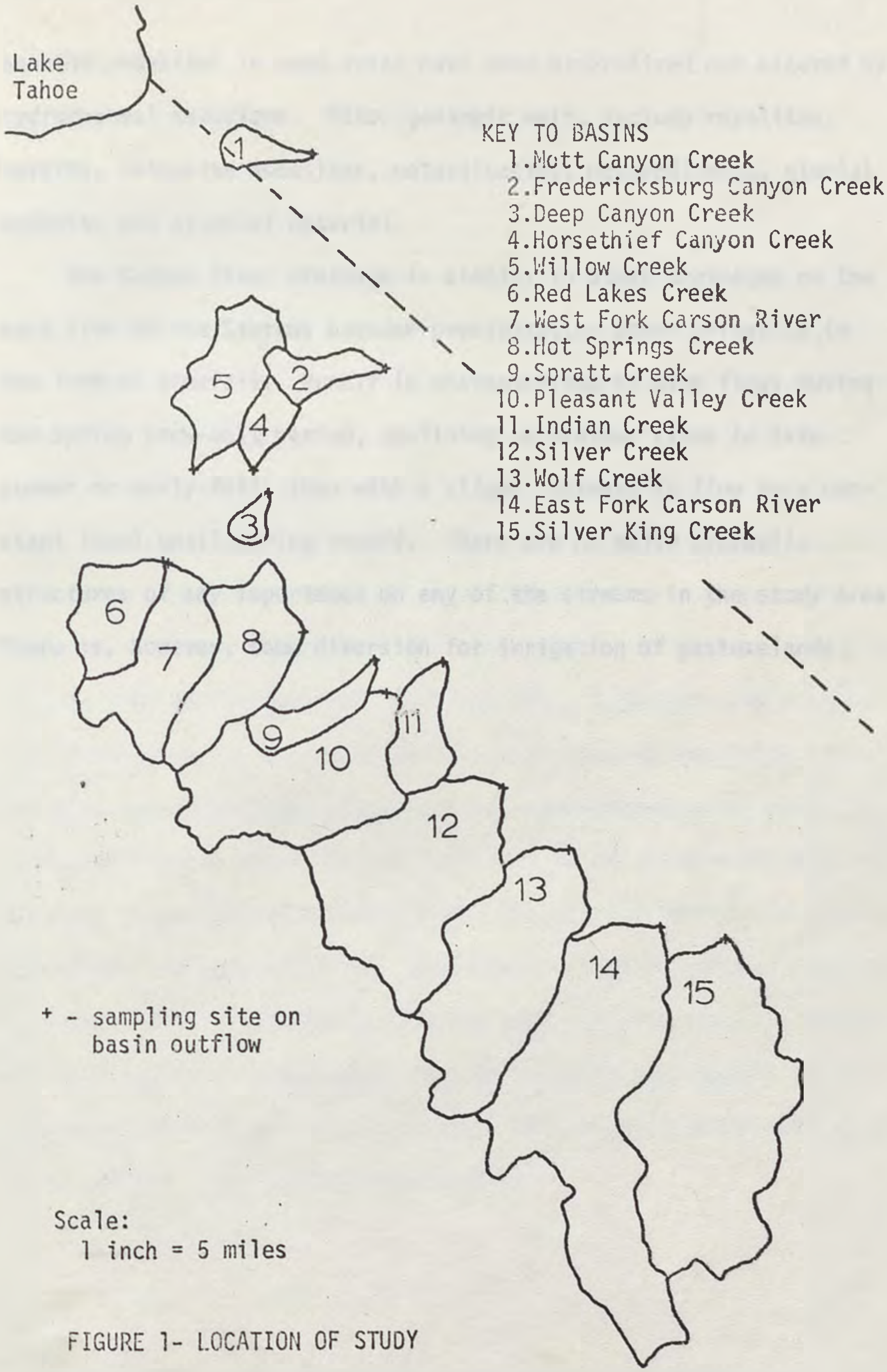


FIGURE 1- LOCATION OF STUDY

and the andesites in some areas have been mineralized and altered by hydrothermal solutions. Minor geologic units include rhyolites, basalts, intrusive andesites, metavolcanics, metasediments, glacial deposits and alluvial material.

The Carson River drainage is similar to other drainages on the east side of the Sierras because precipitation comes primarily in the form of snowfall. Runoff is characterized by high flows during the spring snow-melt period, declining to minimum flows in late summer or early fall, then with a slight increase in flow to a constant level until spring runoff. There are no major hydraulic structures of any importance on any of the streams in the study area. There is, however, some diversion for irrigation of pasturelands.

METHODOLOGY

Selection of Sub-basins

Sub-basins were selected on the basis of three criteria. The first criterion called for selecting basins with wide variation in basin characteristics of geology, soils, geomorphology, and different land uses. This insures the inclusion of basins of divergent patterns for obtaining usable relationships between basin characteristics, and K, n, and ionic ratio values. The second criterion for selecting sub-basins was their contribution to the entire flow system. Sub-basins on the East Fork contribute approximately 85% of the total flow in the river at the gage near Markleeville. Sub-basins on the West Fork contribute approximately 56% of total flow in the river above the gage near Woodfords. These values were determined by comparing flow measurements taken on each tributary to the mean daily flow for that day at the representative gage. The third criterion in selecting sub-basins was accessibility. Most basins could be reached year-round by truck, skis, or snowshoes. Basins that were inaccessible during winter months maintained high flows for a sufficient period to be sampled after they became accessible. This enabled water-quality data to be collected for a wide range in flows.

Sampling Program

A sampling program was conducted from August 1972, to June 1973, on the sub-basins (Locations in Appendix I). Sampling consisted of determining flow with a Pygmy or Price meter and collecting a one gallon water sample for analyses following procedures in Rainwater and Thatcher (1960). Initially samples were taken on a monthly interval until spring runoff when a shorter interval was used. Sampling intervals were chosen to yield two products. First, time variant water chemistry, and second, a wide variation in flows and, concomitantly, water chemistry. Water samples were then analyzed at the Desert Research Institutes' Center for Water Resources Research water analysis laboratory for eleven chemical components. These were eight dissolved ions, $-HCO_3$, $^-Cl^-$, $SO_4^=$, Na^+, K^+, Ca^{++} and Mg^{++}, and SiO_2, pH, specific conductivity, and in selected samples, certain trace ions. The results of the sampling program are presented in Appendix II.

Processing of Flow-Concentration Data

For each sub-basin, the log to the base 10 of the concentrations of HCO_3^-, Cl^-, $SO_4^=$, Na^+, K^+, Ca^{++}, Mg^{++}, SiO_2, total dissolved solids without SiO_2, total dissolved solids with SiO_2, and specific conductivity (S.C.) were separately regressed against the log base 10 of their corresponding flow values to obtain equation of the type

$$\log C = \log K + (-n) \log Q \tag{2}$$

Similar linear form of the equation is

$$Y = a + b\,X \tag{3}$$

where

$Y = \log C$ = concentration

$a = \log K$ = intercept value of regression line

$b = n$ = slope of regression line

$X = \log Q$ = flow value

This linear relationship is seen on a log-log plot as illustrated in Figure 2.

Converting equation (2) to its hyperbolic form yields equation (1)

$$C = KQ^{-n} \tag{1}$$

which is widely used, with modifications in predictive applications (Hall, 1970). Appendix III lists resulting K, n, and correlation coefficient values for each of the 11 chemical components in each

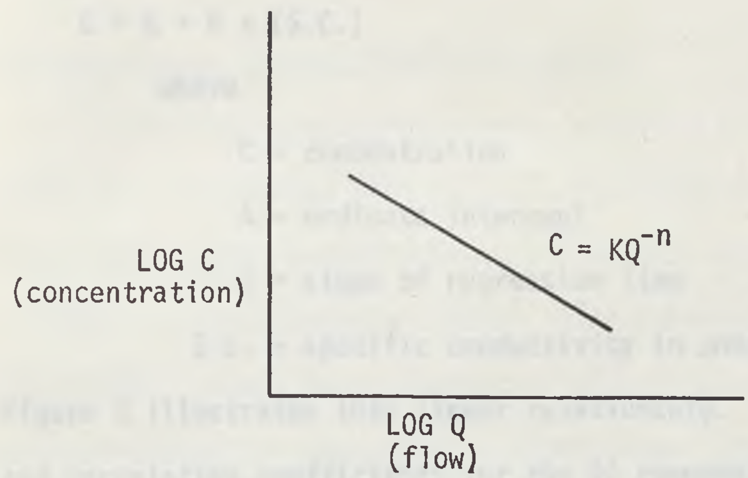


FIGURE 2- TYPICAL FLOW-CONCENTRATION RELATIONSHIP

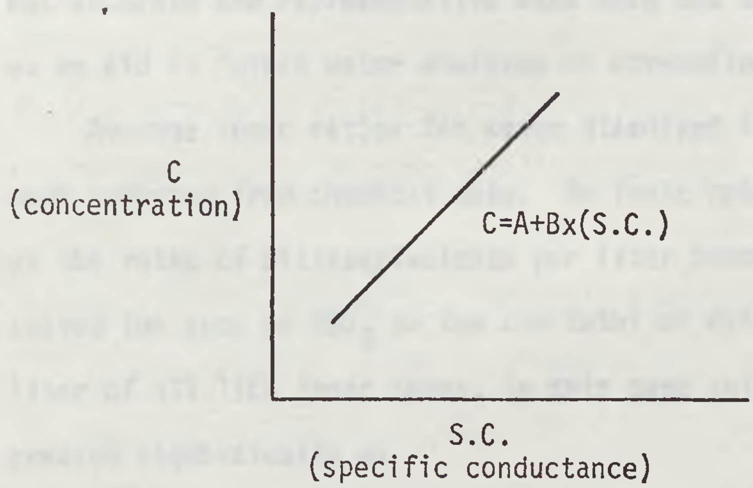


FIGURE 3- TYPICAL SPECIFIC CONDUCTANCE-
CONCENTRATION RELATIONSHIP

sub-basin. Specific conductivity was also regressed against the other 10 chemical components in an arithmatic relation to yield equations of the type

$$C = A + B \times (S.C.)$$

where

C = concentration

A = ordinate intercept

B = slope of regression line

$S.C.$ = specific conductivity in μhos/cm

Figure 3 illustrates this linear relationship. The A and B values and correlation coefficients for the 10 components for each basin are presented in Appendix IV.

Values listed in Appendices III and IV are derived from a short but accurate and representative data base and therefore can be used as an aid in future water analyses or streamflow measurements.

Average ionic ratios for seven dissolved ions in each basin were computed from chemical data. An ionic ratio is defined here as the ratio of milliequivalents per liter concentration of a dissolved ion such as HCO_3^- to the sum total of milliequivalents per liter of all like ionic types, in this case anions. This can be expressed algebraically as

$$IR_{HCO_3} = \frac{\text{meq/l}\,HCO_3}{(\text{meq/l})\text{ all anions}}$$

Similarly, IR for cations can be expressed in the same fashion, The average ionic ratio values for each basin are presented in Appendix V.

Delineation of Sub-basin Characteristics

Sixty-five physiographic basin characteristics for each sub-basin were delineated from U.S.G.S. 15 minute series topographic maps, soils maps, geologic maps, air photos, and some field reconnaissance using Bateman's Truckee River sub-basin characteristics as a guide. Other basin characteristics which Bateman did not use were developed to meet needs of this study. The 65 characteristics can be divided into five broad groups - shape or geomorphic, geology, soils, flow and land use. All values were left in their original form in subsequent computations to avoid ambiguity in determining their physical relation to K, -n, and IR values. Appendix VI is a tabulation of the 65 characteristics for the 15 sub-basins accompanied by a brief description on how each was derived.

Determination of Influential Sub-basin Characteristics

All 65 characteristics were then used as independent variables in stepwise multiple regression against K, then n, and finally IR.

Stepwise multiple regression is a statistical procedure by which regression equations are computed for a dependent variable adding one independent variable per step. The independent variable added is the one with the highest partial correlation with the dependent variable partialed with respect to the independent variables already in the regression equation. This, in effect, reduces the error sum of the squares of the deviation between actual and predicted values (Dixon, 1970). Simply stated the procedure adds the "best" independent variable at each step. Conceptually the "best" independent variable entered is the one with the greatest degree of influence upon the dependent variable. Correlations between characteristics were computed to eliminate highly intercorrelated ones from regression analysis for each of the three dependent variables. A Fisher's Z - test showed that correlations greater than .641 or less than -.641 were significant at the .01 significance level. Characteristics which were removed met one or more of the following criteria.

1. Characteristic eliminated, if it did not enter equation before 6 steps of multiple regression, unless modified by criterion 2.
2. Characteristic eliminated, if highly correlated with another characteristic which has a clearer relationship to the dependent variables or is harder to delineate than the other characteristic.

3. Characteristic eliminated, if not present in a good share of the sub-basins. This was arbitrarily set as those characteristics present in less than eight basins.

After elimination of unneeded characteristics, K was regressed against 17 basin characteristics, n was regressed against 11 characteristics, and IR values were regressed against 15 characteristics. A total of 26 basin characteristics were used in the final regression analyses, some being common to all three regression groups.

Table 2 lists the 26 characteristics used and the number of equations in which each was used. There were a total of 29 multiple regression equations (11 for K, 11 for n, 7 for IR) developed using combination of these 26 characteristics.

Five steps or independent variables were chosen as the limiting number in multiple regression equations to retain simplicity of interaction of characteristics. At five steps only four of the 29 equations had correlation values lower than the .01 significance correlation value extrapolated from Steel and Torrie (1960), a multiple correlation value of approximately .88. Chloride had correlation coefficients of .785 for slope and .792 for ionic ratio. Sulfate regression slope had a correlation coefficient of .834, and sodium regression slope had a correlation coefficient of .746. These four multiple correlation coefficients were tested against the value from Steel and Torrie with the Fisher's Z-test (Snedecor, 1967) and found

TABLE 2

Distribution of Influential Sub-basin Characteristics Among Flow-Concentration Parameters and Ionic Ratios

Characteristics	Number of equations entered into for		
	Intercept	Slope	Ionic Ratio
Minimum Elevation	3	2	0
Median Elevation	4	0	0
Relief Ratio	0	10	3
Average Overland Slope	1	0	0
Total Channel Length	9	0	0
Drainage Density	2	0	0
Texture Ratio	3	6	3
Length of Overland Flow	0	0	3
Stream Frequency	0	0	3
Hypsometric Integral	1	0	0
Form Factor	0	2	2
Circularity Ratio	3	0	C
Elongation Ratio	5	0	0
Percent Area Inceptisols	2	10	1
Percent Area Volcanics	0	2	2
Average Available Water Capacity	0	8	0
Average Soil Depth	3	0	0
Percent by Wt. Sodium	1	0	2
Percent Area Alluvium	1	0	2
Percent Stream Length in Alluvium	0	4	0
Percent Stream Length in Inceptisols	1	0	0
Miles of Road per Square Mile	7	5	5
Mining Activity Coefficient	7	1	3
% North Aspect/% South Aspect	1	5	5
% East Aspect/% West Aspect	1	0	0
Percent Non-Sloping Area	0	0	2

to be not statistically different from the Steel and Torrie value at the .01 significance level (d.f. - 15-2-4 = 9). Although correlation coefficients for these four regressions were less than anticipated, the Fisher's Z-test showed they were not statistically different from the supposed value, therefore, these multiple regression equations were retained for further analysis.

Initial multiple regression equations for sodium regression slope included the characteristic of percent area of metamorphics. When this characteristic was included, the correlation coefficient was .863 at the fifth step. Inspection of this characteristic showed that it was exhibited by only five of fifteen basins. Following criteria for characteristic exclusion, this characteristic was dropped from further computations, causing correlation to decline. Although presence of percent area of metamorphics improved the sodium slope regression, it was excluded because it was not common enough to by physically significant.

The resulting 29 equations are included in Appendix VII. Each regression equation can be interpreted as this example for regression intercept of Total Dissolved Solids without SiO_2.

Intercept Multiple Regression

Total Dissolved Solids Without SiO_2

Variable	Coefficient	F-Value	
Constant	519.55		
Median Elevation	-.046	2.47	R^2 - .9124
Total Channel Length	3.49	34.94	S.E.E. - 31.18
Elongation Ratio	-266.16	5.99	Mean - 131.96
Miles Road per square Mile	-107.27	9.81	
Mining Activity Coefficient	92.54	18.96	

This equation has the form

519.55

-0.046 x (Value of Median Elevation)

-3.49 x (Value of Total Channel Length)

-266.16 x (Value of Elongation Ratio)

-107.27 x (Value of Miles Road per Square Mile)

+92.54 x (Value of Mining Activity Coefficient)

= K TDS w/o SiO_2 for chosen basin

where

F = The F value indicates the relative importance of each characteristic in the equation. The larger the F value the more important the characteristic (Dixon, 1970).

R^2 - This number is the multiple correlation coefficient squared, called the coefficient of determination, and indicates the reduction in the sum of the squares of the deviations between a dependent variable and the predicted value caused by combined effects of independent variable (Steel and Torrie, 1960). The higher this value, the less the uncertainty between predicted and actual values.

S.E.E. - Standard error of estimate indicates relative accuracy of prediction. The smaller this value the better the predictive capabilities.

Mean - This is the average of all fifteen actual values used as dependent variables.

Examination of the equation indicates the effect of increasing or decreasing any one or combination of basin characteristics. The physical meaning of each characteristic and its effect of K, n, and IR values for different constituents will be discussed in the next section.

RESULTS AND DISCUSSION

As stated earlier, some researchers have shown that K and n values are related to different types of measures. The view taken here is that K and n values are dependent on a combination of hydrologic-chemical variables. The twenty-six characteristics considered in the regressions and listed in Table 2 can be divided into two general groups. One group is composed of characteristics which influence movement of water through the basin. This group contains most geomorphic characteristics, some soil characteristics, and the use characteristic of miles of roadway per square mile of basin (RD/A). The second group is composed of characteristics which produce chemical additions to water. This group contains geologic and some soil characteristics and the land use characteristic of mining activity coefficient (MAC). There is some overlap between these two groups, particularly in soil characteristics.

Sub-basin Characteristics - Interpretation

In general, most influential basin characteristics are related to drainage rates. Characteristics inducting relatively rapid drainage are seen to lower K values, lower n values, i.e. "flatten" the regression slope, and produce a favorable exchange or leaching of ions from the lithosphere. The drainage rate effectively governs time of contact between hydrosphere and lithosphere.

Feth, et al,(1964) has shown that mineral content of precipitation (in the form of snow) near the study area is extremely low, from which he concludes that mineral or dissolved ion content of streams in the Sierras is derived almost totally from the lithosphere. Other researchers have also shown that mineral content in the hydrosphere is derived primarily from the lithosphere (Barnes and Bentall, 1968; Miller, 1961; Davis, 1961).

Feth, Roberson, and Polzer (1964) in their definative work on sources of minerals in water in the Sierras also hold this view. Waters they studied were estimated to have derived 95% of their mineral content from the lithosphere. Of the eight dissolved constitutents analyzed for in water samples, Na^+, K^+, Ca^{++}, Mg^{++}, and SiO_2 are derived from solution of geologic materials.

Hydrolysis of silicate minerals is the prime agent in releasing dissolved cations and silica into the hydrosphere. Silicate minerals such aspplagioclase fedlspars are attacked by hydrogen ions from many sources. Keller (1957) lists sources of H^+ as solution of CO_2 from soil atmosphere and air in meteoric water, hydrogen ions on surfaces of acid clays, strong mineral acids primarily those of sulfur, and plant rootlets surrounded by cations (initially H^+). Of these, acid meteoric water, acid clays, and rootlets are most important. Meteoric water combines with CO_2 to form carbonic acid which disassociates to hydrogen ions and bicarbonate as the following reactions illustrates.

$$H_2O + CO_2 \rightleftarrows H_2CO_3$$

$$H_2CO_3 \rightleftarrows H^+ + HCO_3^-$$

Not only is this a primary producer of H^+ but also the main source of HCO_3^- in stream water (Hem, 1970). This source also produces hydrogen ions which attach themselves to negatively charged clay and rootlet surfaces making these two sites further sources for H^+. Interaction of these three sources provide the hydrogen ion supply needed for hydrolysis of geologic material.

Hydrogen ions attack geologic materials to release cations and silica. For example, a general reaction of albite with H^+ is seen to yield Na^+, silica and kaolinite.

$$2NaAlSi_3O8_{(s)} + 2H^+_{(aq)} + 9H_2O_{(l)} \rightleftarrows H_4Al_2Si_2Oq_{(s)} + 4H_4SiO_{4(aq)} + 2Na^+_{(aq)}$$

Albite Kaolinite Silicic Acid Sodium Ion

Similar reactions occur for other feldspars such as orthoclase (K^+) and anorthite (Ca^{++}). Feldspars in the study area are primarily K-feldspars and intermediate plagioclase feldspars. Magnesium can be derived from solution of magnesium rich minerals such as olivines, pyoroxenes, and amphiboles. These minerals are all common in rocks in the study area. An example reaction between magnesian olivine and hydrogen ions illustrates how Mg^{++} enters the hydrosphere.

$$5Mg_2SiO_4 + 8H^+ + 2H_2O \rightleftarrows Mg_6(OH)_8Si_4 + 4Mg^{+2} + H_4SiO_4$$

Forsterite Serpentine

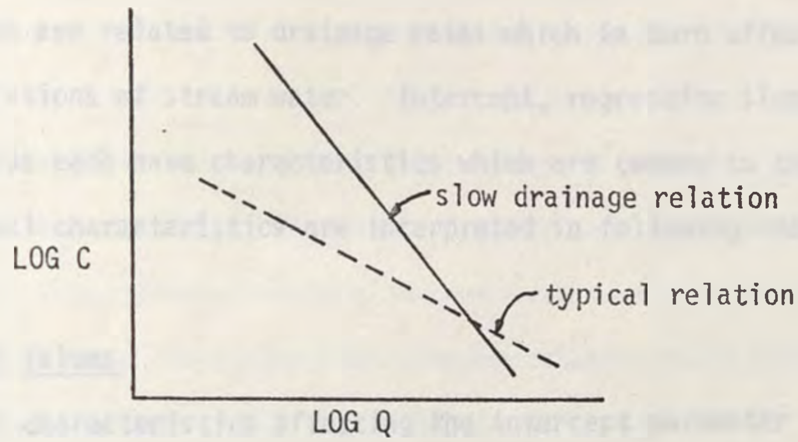
Reactions presented above show that hydrolysis of various igneous minerals yields cations and H_4SiO_4 or silicic acid. Although the reactions imply that silica is bound in silicic acid, this may not be the case. Silica has several polymers and any one of these may be present upon solution of an igneous rock. Silica reported in the chemical analysis as SiO_2 could really be any one of several different polymers because of the method used for determination of silica. (Pat Harris, personal communication, 1973). By convention, silica is reported as SiO_2 to provide comparable data between samples.

Two other dissolved ions present, chloride and sulfate, are relatively rare compared to the other ions in geologic materials in the area. Most streams have low concentrations of chloride and sulfate, which are primarily derived from precipitation (Feth, Roberson, Polzer, 1964). Streams that do exhibit higher concentrations of chloride and particularly sulfate derive these anions from mineralized sources. Either thermal waters or, as is the case in the study area, mining activity are prime sources of these anions. In general, chloride and sulfate can only be roughly predicted by flow-concentration equations and therefore their corresponding K, n, and IR values may not be rigidly related to basin characteristics which are common to other ions.

The drainage rate or contact time between lithosphere and hydroshere is very important on the amount of dissolved ions entering the hydrosphere. Grahm (1941) shows that acid (H^+) - anorthite solutions will reach equilibrium if left undisturbed. That is cations entering solution from replacement by H^+ will eventually reach a steady concentration, which implies that if geologic materials were to drain slowly, ionic concentrations of Ca^{++}, Na^+, K^+, Mg^{++}, SiO_2, and HCO_3^- would increase until H^+ was no longer available or cations were inaccessible for hydrolysis. Basin characteristics which enhance drainage should therefore lower ionic concentrations due to the decreased contact time. Regression equations developed for K and n support this assumption as characteristics indicative of relative good drainage seem to lower intercepts and "flatten" regression line slopes. Physically, lower K values indicate higher quality water at all flows, i.e. lower ionic concentrations. Flatter slopes indicate that water quality is fairly consistent at all flows. Implications of "flatter" slopes are three-fold.

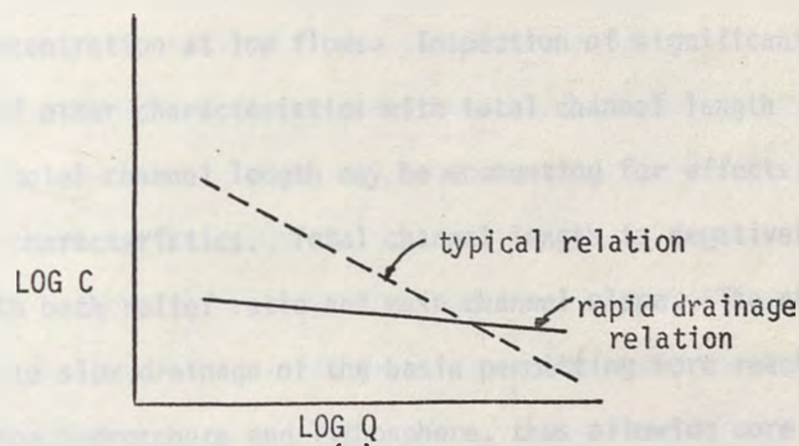
First, regression lines may be "pivoted" around concentration values at low flows, thus, increasing high flow concentrations. Second, regression line may be "pivoted" around a central value of intermediate flow and concentration, thus reducing low flow concentrations and increasing high flow concentrations. Third, regression lines may be "pivoted" around high flow values thus reducing concentrations at all flows. Choice three seems to be most approrpiate for two reasons. First, water analyses show that high flows (snowmelt) are characterized by high quality. Second, as previously suggested, characteristics which enhance drainage will help lower intercept values and help "flatten" slopes. These simultaneous actions indicate that the regression line is being pivoted around the high flow values lowering K and flattening the slope. Figure 4 shows how changing the parameters effects a hypothetical flow concentration relation.

Conversely, characteristics which retard drainage will raise K values, increase ionic concentration, and "steepen" regression line slopes. A steeper regression line indicates a great difference in ionic concentrations between high and low flows. High flows in this case are characterized by snowmelt while low flows are characterized by a relatively highly concentrated slowly draining ground water component. Ionic ratios are also controlled by drainage. Most notable are characteristics related to Na^{+} and Ca^{++}. This will be discussed in a later section.



(a)

Increased K
Increased n



(b)

Lower K
Lower n

FIGURE 4- EFFECTS OF CHANGING K AND n VALUES
(a) sub-basin with slow drainage
(b) sub-basin with rapid drainage

Intercept, regression slope, and ionic ratio values are related to various hydrologic-chemical basin characteristics. Most of these characteristics are related to drainage rates which in turn affect ionic concentrations of stream water. Intercept, regression slope, and ionic ratios each have characteristics which are common to them. These individual characteristics are interpreted in following sections.

Intercept or K Values

Important characteristics affecting the intercept parameter (K) are total channel length, elongation ratio, RD/A, and MAC. Total channel length consistently raises the value of K, in effect increasing concentration at low flows. Inspection of significant correlations of other characteristics with total channel length indicate that total channel length may be accounting for effects of several other characteristics. Total channel length is negatively correlated with both relief ratio and main channel slope. The effect here would be to slow drainage of the basin permitting more reaction time between the hydrosphere and lithosphere, thus allowing more dissolved solids to enter the water. Total channel length is positively correlated with low flow implying releases from bank storage of lower quality water. Bateman (personal communication, 1973) has noted that total channel length correlates with improved water quality at low flows for Truckee sub-basins. There may be underlying factors, such as materials being weathered, which although not apparent, are causing disparity between Truckee and Carson sub-basins with respect to the influence of total channel length.

Elongation ratio is another influential basin characteristic. The role this characteristic has in lowering the value of K, i.e. inducing higher quality water, is not fully understood at this time. Other primary characteristics, RD/A and MAC, will be discussed in a later section. Minor characteristics such as texture ratio, average soil depth, and % area inceptisols can also be related to drainage and reaction times of water with the lithosphere.

Slope or *n* Values

Relief ratio, percent area in inceptisols, texture ratio, percent north aspect divided by percent south aspect, (NA/SA), average available water capacity and miles of roads per square mile are the most frequent characteristics in slope multiple regression equations. Relief ratio is a measure of basin slope and therefore will influence drainage rates. As the equations show, (Appendix VI) the higher relief ratio becomes, the flatter the regression slope. That is higher basin slopes cause faster drainage rates. Percent area in inceptisols is indicative also of drainage. Inceptisols in the study area are characteristically well drained with moderate to rapidly moderate permeability. This characteristic of good drainage will also flatten slopes in the multiple regression equation. Texture ratio, on the other hand, makes n values more negative, or steepens the regression line slope. This effect is possibly a result of texture ratio being a measure of weathering or erosion of a basin. A more eroded basin would tend to drain slower than a less eroded basin thereby adding more dissolved solids at low flows. High flows on the other hand would not be affected because the decomposed basin would saturate with initial snowmelt thereby sending excess snowmelt directly into the stream. Percent north aspect divided by percent south aspect increases regression slopes because of its relation to the melting rate of a snowpack. The more north aspect, the slower the melt, the higher the infiltration volume, and the larger the chemical ground water component at low flows. High flows still rely on excess high quality snowmelt. Average available water capacity increases regression slopes. Once again a large, ground water component is dominant at low flows while at high flows excess melt is delivered into the stream. Miles of roads per square mile of basin will be discussed in a later section. Minor influencing characteristics all reflect similar properties as the primary characteristics, those of drainage and saturation.

Ionic Ratio Values

Ionic ratios are interrelated within their respective groups of anions and cations. A basin characteristic which increases the ionic ratio of one constitutent, in general, must reduce one or more others in the group. An example of this would be exchange of Ca^{++} for Na^{+} in a slowly drained clayey soil. A characteristic showing this effect is NA/SA. This characteristic effects drainage time by slowing melting of a snowpack. As the pack melts, the underlying soil becomes saturated. The soil will remain in this condition as long as there is a sufficient snowcover. During this period, Ca^{++} will selectively replace Na^{+} on clay structures thereby raising Na^{+} concentration and lowering Ca^{++} concentration. This is precisely what this NA/SA implies in Ca^{++} and Na^{+} regressions. Characteristics of fast drainage, however, reverse this relationship because Ca^{++} does not have adequate residence time to exchange for Na^{+} in certain clays.

Influence of Land Use Characteristics

Only two land use factors, miles of roadway per square mile of basin (RD/A) and mining activity coefficient (MAC), were used in this study. Surprisingly they both were good indicators of parameters being studied. Of these characteristics RD/A was the most prevalent in multiple regression equations. This characteristic entered seventeen of twenty-nine equations generated, seven times for K, five times for n, and five times for IR. The RD/A characteristic consistently produced similar effects. These effects showed RD/A to be related to rapid drainage. The road density, another name for RD/A, consistently lowered K values and flattened regression slopes, lowered values. The road density function also increased calcium ionic ratio while lowering sodium ionic ratio. All of these results are interpreted as being related directly to rapid drainage. As a land use practice, this would imply that, taken to an extreme, if the whole basin were roadway, water quality would be excellent. However, because drainage would be so increased by this action, there would be only a spring runoff with little or no base flow. This situation is not an equitable trade for improved water quality. Also, the largest fraction of roadways in study sub-basins was composed of unimproved dirt roads and therefore do not have the inherent runoff-quality problems found with paved, urbanized roadways (FWPCA, 1969).

The other land use characteristic, MAC, was innovated by the author specifically for this study. The MAC characteristic is a measure of mining activity and therefore mineralization or alteration in a basin. MAC was conceptualized to account for higher concentrations of total dissolved solids, particualrly Ca^{++} and $SO_4^{=}$, in basin outflow waters. The area was heavily mined in the second half of the eighteenth century and some mining activity is still carried on today. During the peak, disposal of tailings was not of grave concern to miners and therefore many tailings dumps were placed directly in streambeds. Because much of the ore was in the form of sulfides, the dumps became sites for sulfate production. The resulting waters were made acidic because of H_2SO_4 production.

To alleviate this problem, some dumps were limed to produce a neutralizing base reaction. This is evidenced by both high concentrations of $SO_4^=$ and Ca^{++} from these areas. Another possible source of calcium could be from tailings themselves. Calcium could be present in some form in the tailings and be leached out by reaction with H_2SO_4. In other areas, calcium is derived from metamorphosed roof pendants (Parker, 1961). Another attribute of MAC is its statistical correlation with higher K values. All but three MAC values are unity. However, those which are greater than unity are linearly related to MAC and significantly correlated. Although MAC is not a rigorous characteristic, as a generalized measure of a basin property it seems to fill a need and produce the supposed response in the system. A better measure of mineralization and mining activity in a basin might be to delineate mine dumps or mineralized areas in a percent area fashion. For purposes of this study, the simplistic approach taken appears to be adequate.

Predictive Capabilities of Multiple Regression Equations'

The primary use of the 29 generated regression equations is for determination of which basin characteristics are related to selected quality parameters. For this purpose the equations are quite illustrative as to the influence of each important characteristic. Use of these same regression equations for predictive purposes appears to be limited. As an example, the intercept value K for specific conductance can be expressed by an equation (Appendix VII) which has an R^2 value of .9082. However, this percent variance explained is considered for all 15 basins. If each basin is examined separately and the percent deviations between actual and predicted values are calculated, the individual deviations range from -38 to +75 percent. A better indication of these large deviations is given by the standard error of estimate. The standard error of estimate (S.E.E.) is a measure of scatter of predicted actual data pairs about a line of precise prediction. Therefore, the larger the S.E.E., the more scatter and the worse the predicted value is in error. In this example S.E.E. is 31.18, a relatively large value compared to the mean, indicating that predictions will be poor.

Further examination of predicted values yields little. There is no discernable pattern to the predictions, such as high predictions for low values or low predictions for high values. Bateman (personal communication) has encountered similar problems for Truckee sub-basins predictive equations. This study was not conducted to enable precise and individual prediction of selected quality parameters. It was conducted to yield a better insight into which physical characteristics influence the parameters. To that point, generation of regression equations for different parameters has been successful in that regression equations have yielded self-explanatory relationships between parameters and characteristics. Use of regression equations for predictive purposes is therefore cautioned against.

Comparison of Truckee River and Carson River Sub-basin Characteristics

Although the number of sub-basins studied for each river was different, many characteristics "on the average" did not display a significant difference. Physically, Carson sub-basins are bigger, higher, and steeper than Truckee sub-basins. Carson sub-basins also have more granitic material and less volcanic and glacial material. Soil characteristics of average soil depth and available water capacity are noticeably lower in Carson sub-basins. Chemically, Carson intercept values are usually higher than Truckee K values. Regression slope values tend to indicate steeper slopes for most chemical components in Carson sub-basins, notably Cl^- and $SO_4^=$. This is caused by mineralization in the Carson sub-basins. Ionic ratios are comparable for both basins, differences being in higher mean values for $SO_4^=$ and a lower value for Cl^-. Chloride is lower because of the effect of winter road salting on water quality in Truckee Basin tributaries. In general, Carson sub-basins are eroded less and are more chemically active than Truckee sub-basins. Influential characteristics for Truckee intercept and regression slopes were compared to influential characteristics in Carson sub-basins. Characteristics which were not common to both sub-basins sets were examined with aid of Carson sub-basin characteristic correlations. This was done to determine which influential Carson characteristics represented, conceptually or directly, influential Truckee characteristics. As an example, stream order (effectively a measure of basin size) has a strong negative influence on regression line slope for Truckee sub-basins. For Carson sub-basins, stream order is negatively correlated with relief ratio, a strong positive influence in slope multiple regression equations. Although the signs are different, thus having different effects, the sign convention is consistent with the correlation between these two characteristics, and therefore their conceptual relationship is easier to perceive. Similar analyses were done for all influential Truckee sub-basin characteristics as delineated by Bateman. Relationships were not always clear from intercorrelations, but were conceptually consistent. Similar influential sub-basin characteristics are discussed in following sections.

Intercept (K) Values

Table 3 lists influential Truckee sub-basin characteristics and their Carson counterparts which define intercept values.

TABLE 3

Comparison of influential Truckee Sub-basin and Carson Sub-Basin Characteristics for Intercept Values (K).

Truckee Characteristic	Representative Carson Characteristic
Average Effective Basin Width	Total Channel Length
% Area Igneous Rock	Mining Activity Coefficient
% Area Alfisols + Mollisols	Mining Activity Coefficient
Flow Variation Factor	Total Channel Length
Average Soil Depth	Average Soil Depth
Median Elevation	Median Elevation
% Sodium in Igneous Rock	% by Wt. Na^+

Bateman delineated seven characteristics all of which are represented by Carson sub-basin characteristics and are related to intercept values. This total agreement indicates that similar hydrologic-chemical relationships influence intercept values in both river basins.

Similarities also exist between Truckee and Carson influential sub-basin characteristics for regression slope values.

Slope (n) Values

Table 4 lists Truckee sub-basin characteristics, which define regression slope values, with their representative Carson sub-basin counterparts.

TABLE 4

Comparison of Influential Truckee Sub-basin and Carson Sub-basin Characteristics for Regression Slope Values (n)

Truckee Characteristic	Representative Carson Characteristic
Stream Order	Relief Ratio
% Area Alfisols + Mollisols	% Area Inceptisols
Texture Ratio	Texture Ratio
% Area Grantic Rock	% Area Inceptisols
Flow Range	Average Available Water Capacity
Degree of Human Use	Miles of Road per Square Mile
Average Soil Permeability	% Area Inceptisols
Channel Slope	Relief Ratio

Thirteen characteristics were delineated for Truckee basins, of which eight could be conceptually or actually related to Carson characteristics for regression slope values. This indicates once again that similar hydrologic-chemical controls are affecting regression slope values.

Similarities between Truckee and Carson sub-basin characteristics influential in defining intercept and slope values is quite striking. These similarties suggest that controls on the flow-concentration relationship are consistant between these two river basins. Although not performed, a test of this hypothesis would be to combine data from Truckee and Carson sub-basins for multiple regression analysis. This type of combined analysis would help indicate if similarities between basin characteristics are real, which appears to be the case, or coincidental. Combination of the two sets of data would also help refine the determination of influential characteristics by providing a larger data base.

Similarities between influential characteristics in Truckee and Carson sub-basins show that methods for determining characteristics influential to flow-concentration relationships is valid. Validity of this supposition could be tested by application of these methods to another set of river sub-basins in the region.

CONCLUSIONS

Flow-concentration regressions were developed for eleven inorganic chemical components from fifteen Upper Carson River subbasins. Chemical data from water analyses of samples gathered between August 1972, and June 1973, also yielded average ionic ratios for seven dissolved inorganic ions. Analysis of the fifteen sub-basins yielded sixty-five physiographic basin characteristics (geomorphic, geologic, soils, land use, flow) for each sub-basin. These characteristics were multiply regressed against selected flow-concentration regression parameters and ionic ratios. The multiple regression equations developed aided interpretation of hydrologic-chemical influences on these parameters.

Values of K and n are lower in basins where physiographic characteristics provide for relatively good drainage. This occurs because a well drained basin does not allow water time to react with and leach ions from geologic materials and soils. Conversely, a basin where physiographic characteristics retard drainage exhibit higher K and n values.

Similar conclusions were reached with respect to ionic ratios. Basins which exhibit poor drainage characteristics have higher ionic ratios of ions which are slowly leached from geologic materials.

Multiple regression equations for flow-concentration regression parameters and ionic ratios were inspected to determine their predictive capabilities. Although the highly correlated multiple regressions equations were useful in determining influential basin characteristics, their predictive capabilities were poor. This dichotomy is caused by the counter balancing of high and low individual predictions which "on the average" produce a statistically good multiple regression equation. The use of these multiple regression equations for predictive work other than general insight into controls on water chemistry is cautioned against.

Similarities between influential sub-basin characteristics for Truckee and Carson sub-basins were investigated to determine the transferability between river basins. Results indicate that similar hydrologic-chemical controls influence behavior of flow-concentration relationships in both river basins. These results show that future analyses of sub-basins for determination of influential characteristics on flow-concentration relationships need only be done with respect to selected physiographic basin characteristics.

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APPENDICES

APPENDIX I

Sample Site Location

Sub-Basin #	Name	Location (based on Mount Diablo) (Base Meridian)
1)	Mott Canyon Creek	NE 1/4, SE 1/4, Sec 4, T12N, R19E - above diversions above Nevada Route 19.
2)	Frederickburg Canyon Creek	NE 1/4, SW 1/4, Sec 12, T11N, R19E - above diversions at mouth of canyon.
3)	Deep Canyon Creek	SW 1/4, SE 1/4, Sec 32, T11N, R19E - below Highway 88-89
4)	Horsethief Canyon Creek	SW 1/4, NW 1/4, Sec 32, T11N, R19E - 150 feet above Highway 88-89
5)	Willow Creek	SW 1/4, E 1/2, Sec 24, T11N, R18E - 100 feet above confluence with West Fork Carson River
6)	Red Lakes Creek	NW 1/4, NE 1/4, Sec 7, T10N, R19E - above confluence with West Fork Carson River
7)	West Fork Carson River	NW 1/4, NE 1/4, Sec 7, T10N, R19E - above confluence with Red Lakes Creek
8)	Hot Springs Creek	SW 1/4, NW 1/4, Sec 24, T10N, R19E - above inflow from Grovers Hot Springs
9)	Spratt Creek	NE 1/4, NW 1/4, Sec 29, T10N, R20E - above confluence with Hot Springs Creek
10)	Pleasant Valley Creek	NW 1/4, SE 1/4, Sec 32, T10N, R20N - at end of Pleasant Valley
11)	Indian Creek	NW 1/4, NE 1/4, Sec 27, T10N, R20E - above confluence with East Fork Carson River

APPENDIX I

Sample Site Location

Sub-Basin #	Name	Location (based on Mount Diablo) (Base Meridian)
12)	Silver Creek	NW 1/4, NE 1/4, Sec 13, T9N, R20E - above Wolf Creek Meadows road
13)	Wolf Creek	NW 1/4, NE 1/4, T9N, R21E - at bridge at end of Wolf Creek Meadow
14)	East Fork Carson River	SW 1/4, SW 1/4, T8N, R21E - at Soda Springs Guard Station Trail
15)	Silver King Creek	SW 1/4, SW 1/4, T8N, R22E - above irrigation diversions to Silver King Valley

APPENDIX II

Flow and Chemical Data for Upper Carson Sub-basins: Values in mg/l Except Date of Sample, Flow (cfs) and Specific Conductance (umhos/cm)

MOTT CANYON CREEK

Date	8/3/72	9/9/72	10/7/72	11/3/72	12/2/72	1/2/73	5/19/73
Flow	1.33	1.78	1.64	2.36	1.80	2.61	3.01
HCO_3^-	50.09	50.14	51.13	49.79	48.09	49.36	47.60
Cl^-	.32	.22	.36	.34	.52	.40	.18
$SO_4^=$	.50	.50	.50	.50	.50	.50	.50
Na^+	4.57	4.30	4.80	4.60	4.40	4.50	3.60
K^+	1.60	1.10	1.50	1.40	1.73	1.77	1.77
Ca^{++}	8.80	9.00	9.50	9.00	8.70	9.20	8.70
Mg^{++}	1.60	1.70	1.50	1.70	1.60	1.60	1.60
SiO_2	18.50	19.50	19.00	18.75	17.40	19.50	18.46
TDS without SiO_2	67.48	66.96	69.29	67.32	65.54	67.33	63.95
TDS with SiO_2	85.98	86.46	88.29	86.07	82.94	86.83	82.35
Specific Conductance	76.60	77.83	90.16	77.43	75.96	76.53	75.76

FREDERICKSBURG CANYON CREEK

Date	8/3/72	9/15/72	10/7/72	11/3/72
Flow	3.39	2.58	2.60	2.48
HCO_3^-	37.30	38.64	36.70	37.10
Cl^-	.37	.98	.41	.43
$SO_4^{=}$	2.20	2.50	2.30	2.20
Na^+	3.70	3.70	4.00	4.00
K^+	1.60	1.40	1.40	1.80
Ca^{++}	6.20	7.00	6.70	6.40
Mg^{++}	1.60	1.70	1.30	1.60
SiO_2	20.90	36.38	22.50	21.25
TDS without SiO_2	52.97	55.92	52.81	53.03
TDS with SiO_2	73.87	92.30	75.31	74.28
Specific Conductance	59.20	62.09	61.66	61.14

12/2/72	1/2/73	5/19/73	5/28/73	6/19/73
2.31	2.14	4.54	9.50	5.35
37.97	38.40	33.00	27.80	35.45
.40	.40	.25	.32	.21
2.30	2.40	1.50	.50	.50
4.20	4.25	2.80	2.40	3.40
1.61	1.65	1.45	1.19	.148
6.60	6.90	5.75	4.60	5.75
1.60	1.50	1.40	1.30	1.45
20.10	21.20	18.30	19.20	22.00
54.68	55.40	46.15	38.11	48.24
74.78	76.60	64.45	57.31	70.24
63.07	62.00	54.62	46.56	55.25

DEEP CANYON CREEK

Date	8/4/72	9/9/72	10/7/72	11/3/72
Flow	.92	.61	.62	.64
HCO_3^-	41.45	48.67	43.79	40.69
Cl^-	.41	.42	.45	.62
$SO_4^=$	.50	.50	.50	.50
Na^+	2.98	2.88	2.50	2.60
K^+	1.80	1.70	2.40	1.50
Ca^{++}	5.10	6.20	6.00	4.80
Mg^{++}	3.70	4.10	3.60	3.70
SiO_2	28.50	26.00	29.50	28.25
TDS without SiO_2	55.94	64.47	59.24	54.41
TDS with SiO_2	84.44	90.47	88.74	82.66
Specific Conductance	63.20	67.92	67.90	64.91

12/2/72	4/20/73	5/23/73	6/8/73
.44	1.59	15.86	8.61
43.03	44.43	33.20	29.80
.63	.32	.34	.25
.50	.50	.50	.50
2.60	2.70	1.80	1.60
1.81	1.72	1.58	1.64
5.80	5.70	4.35	3.85
3.60	3.60	2.65	2.55
28.10	28.60	26.50	23.30
57.97	58.97	44.52	40.19
86.07	87.57	71.02	63.49
67.49	70.45	52.20	49.60

HORSETHIEF CANYON CREEK

Date	8/4/72	9/9/72	10/7/72	11/3/72	12/2/72
Flow	1.16	1.41	1.52	1.57	1.75
HCO_3^-	51.81	53.09	51.13	47.87	45.56
Cl^-	.31	.42	.32	.50	.67
$SO_4^=$	1.70	.50	1.90	1.96	1.60
Na^+	4.20	4.20	4.20	4.30	4.20
K^+	1.80	1.80	2.50	1.60	1.30
Ca^{++}	8.00	7.70	8.10	7.00	7.10
Mg^{++}	3.30	3.40	2.80	3.00	2.50
SiO_2	30.00	42.25	29.00	28.50	25.80
TDS without SiO_2	71.12	71.11	70.95	66.23	62.93
TDS with SiO_2	101.12	113.36	99.95	94.73	88.73
Specific Conductance	82.40	85.54	80.63	76.12	72.05

1/2/73	4/4/73	4/20/73	6/19/73
1.75	2.27	4.12	2.98
45.16	43.45	41.50	46.45
.45	.35	.28	.21
2.10	.50	.50	.50
4.10	3.35	3.38	3.50
1.77	1.75	1.42	1.58
7.20	6.50	6.00	6.75
2.50	2.60	2.35	2.60
28.50	26.60	26.50	28.00
63.28	58.50	55.43	61.59
91.78	85.10	81.93	89.59
71.92	70.15	63.95	72.60

WILLOW CREEK

Date	8/3/72	9/9/72	10/7/72	11/3/72
Flow	2.93	3.25	6.94	7.03
HCO_3^-	39.72	44.24	27.97	27.53
Cl^-	.83	.55	.36	.36
$SO_4^=$	.50	.50	1.75	2.38
Na^+	4.15	4.40	3.60	3.60
K^+	1.10	1.20	1.20	1.06
Ca^{++}	7.00	8.20	4.90	4.50
Mg^{++}	1.70	1.80	1.10	1.10
SiO_2	24.20	28.38	19.50	19.50
TDS without SiO_2	55.00	60.89	40.88	40.53
TDS with SiO_2	79.20	82.27	60.38	60.03
Specific Conductance	62.10	74.11	46.45	45.33

12/2/72	1/2/73	4/19/73	6/8/73
8.44	8.00	13.20	41.51
27.34	27.34	27.30	14.60
.34	.33	.28	.14
.50	2.10	1.80	1.80
3.30	3.00	3.20	1.75
1.07	1.13	1.01	.86
4.40	4.80	4.46	2.45
1.00	1.10	11.05	.60
17.70	19.50	15.70	12.50
37.95	39.80	39.40	22.68
55.65	59.30	54.74	35.18
45.87	46.25	42.26	25.60

RED LAKES CREEK

Date	8/3/72	9/9/72	10/7/72	11/3/72	12/2/72
Flow	33.68	.996	1.65	1.26	1.05
HCO^-_3	32.82	59.58	62.02	53.85	55.69
Cl^-	.41	.86	.74	.60	.75
$SO^=_4$	3.00	7.05	9.70	9.25	10.40
Na^+	2.05	3.22	3.40	3.40	3.20
K^+	1.20	.90	1.00	.60	.92
Ca^{++}	6.90	14.60	16.30	14.20	14.80
Mg^{++}	2.00	3.20	2.70	2.75	2.70
SiO_2	9.30	22.25	18.00	17.50	18.50
TDS without SiO_2	48.38	89.41	95.86	84.65	88.46
TDS with SiO_2	57.68	111.66	113.86	102.15	106.96
Specific Conductance	56.10	110.50	113.70	106.00	112.50

5/23/73	6/26/73
80.08	15.54
29.30	30.60
.40	.10
2.60	3.20
1.45	1.70
.66	.65
6.42	7.25
1.55	1.45
11.00	12.60
42.38	44.95
53.38	47.55
52.20	57.91

WEST FORK CARSON RIVER

Date	10/7/72	11/3/72	12/2/72	4/9/73
Flow	3.61	3.95	4.76	34.03
HCO^{-}_{3}	29.87	28.72	30.88	18.45
Cl^{-}	.47	.46	.50	.65
$SO_4^{=}$	2.10	2.42	2.60	.50
Na^{+}	2.10	2.20	1.90	1.45
K^{+}	.30	.33	.78	.29
Ca^{++}	6.60	6.00	6.50	3.65
Mg^{++}	1.40	1.70	1.60	1.00
SiO_2	8.00	12.00	8.10	8.75
TDS without SiO_2	42.84	41.83	44.76	25.99
TDS with SiO_2	50.84	53.83	52.86	34.74
Specific Conductance	55.93	48.99	52.36	32.18

4/19/73	5/23/73
39.60	145.52
20.75	17.33
.26	.21
.50	.50
1.80	.95
.32	.24
3.85	3.50
1.00	.85
8.50	7.50
28.48	23.58
36.98	31.08
30.14	27.66

HOT SPRINGS CREEK

Date	8/4/72	9/9/72	10/7/72	11/4/72	12/7/72	1/4/73	4/19/73	5/23/73
Flow	1.73	.895	1.71	6.91	4.02	8.85	31.11	168.29
HCO^-_3	52.51	61.94	59.48	38.30	41.77	37.70	26.85	20.30
Cl^-	2.45	2.60	2.02	.92	1.30	1.02	.40	.16
$SO_4^=$	2.60	2.65	2.73	2.14	1.90	2.40	.50	.50
Na^+	6.13	7.10	6.20	3.80	4.20	3.90	2.90	1.60
K+	1.00	1.00	1.00	.30	.64	.56	.46	.39
Ca++	9.10	11.00	11.10	7.00	7.80	7.20	4.60	3.65
Mg^{++}	2.50	3.10	2.50	2.20	2.00	1.80	1.25	1.20
SiO_2	17.10	20.00	18.20	12.00	13.80	15.00	11.40	9.30
TDS without SiO_2	76.29	89.39	85.03	54.65	59.61	54.58	36.96	27.80
TDS with SiO_2	93.39	119.39	103.23	66.66	73.41	69.58	48.36	37.10
Specific Conductance	89.00	108.90	97.02	65.23	71.51	62.93	40.39	33.36

SPRATT CREEK

Date	8/4/72	9/10/72	10/7/72	11/4/72	1/4/73
Flow	.32	.28	.82	2.11	2.43
HCO^-_3	82.90	98.81	93.66	66.41	61.26
Cl^-	.41	.42	.56	.54	.70
$SO_4^=$	1.90	.50	.50	1.85	2.10
Na^+	5.39	6.10	6.60	4.60	4.10
K^+	1.00	.80	.90	.70	.73
Ca^{++}	15.66	18.80	18.20	13.10	12.70
Mg^{++}	4.00	4.90	4.00	3.40	2.90
SiO_2	18.10	31.25	19.20	15.75	17.50
TDS without SiO_2	111.20	130.33	124.42	90.60	84.49
TDS with SiO_2	129.30	161.58	143.62	106.35	101.99
Specific Conductance	126.50	151.60	136.60	104.50	99.55

4/5/73	4/19/73	5/23/73
4.72	10.26	35.78
77.14	52.00	26.36
.25	.25	.18
.50	.50	.50
4.85	3.10	1.50
.82	.51	.41
14.20	10.05	5.00
3.50	2.45	1.40
16.90	14.00	10.70
101.26	68.86	35.35
118.16	82.86	46.05
111.70	82.36	42.97

PLEASANT VALLEY CREEK

Date	8/8/72	9/10/72	10/8/72	11/4/72
Flow	19.29	5.46	8.16	9.97
HCO_3^-	58.03	87.89	81.51	76.59
Cl^-	.45	.28	.38	.57
$SO_4^=$	3.60	7.40	5.30	4.30
Na^+	3.52	5.05	5.20	4.60
K^+	.90	1.00	.60	.80
Ca^{++}	11.70	19.60	18.00	15.70
Mg^{++}	3.00	5.00	3.80	4.00
SiO_2	13.50	28.00	16.50	16.75
TDS without SiO_2	81.20	126.22	114.79	106.56
TDS with SiO_2	94.70	154.22	131.29	123.31
Specific Conductance	93.70	152.70	130.40	126.00

12/7/72	1/4/73	4/5/73	4/19/73	6/19/73
8.79	19.32	25.32	56.95	62.71
77.96	60.75	70.80	49.80	44.00
.42	.45	.32	.18	.30
8.20	5.40	6.30	3.30	2.40
4.60	3.80	4.00	2.85	2.50
.96	.83	.82	.58	.58
18.00	14.10	15.40	10.45	8.50
3.80	2.90	3.40	2.50	2.25
15.20	14.70	14.00	10.20	13.50
113.94	88.23	101.04	69.66	60.53
129.14	102.93	115.04	79.86	74.03
138.40	106.60	121.00	86.43	64.20

INDIAN CREEK

Date	8/8/72	9/10/72	10/7/72	11/3/72	12/2/72
Flow	.10	.07	.18	.30	1.05
HCO^{-}_{3}	101.90	130.20	108.80	125.60	132.90
Cl^{-}	1.01	1.15	1.02	.87	.80
$SO_4^{=}$	401.60	447.00	316.40	228.60	114.80
Na^{+}	20.10	26.00	18.00	15.70	9.60
K^{+}	2.50	1.90	2.60	1.52	1.07
Ca^{++}	142.40	148.00	120.00	89.20	60.00
Mg^{++}	23.70	30.00	18.00	17.30	12.20
SiO_2	23.80	37.50	18.75	18.75	15.80
TDS without SiO_2	693.21	757.25	584.82	478.79	331.27
TDS with SiO_2	717.01	794.75	603.57	497.54	347.17
Specific Conductance	773.80	873.50	651.00	567.60	422.80

1/4/73	3/29/73	4/19/73
1.68	5.19	9.63
119.50	88.88	86.90
.50	.45	.25
94.00	44.40	23.50
8.80	5.80	6.35
1.00	.94	.79
55.40	32.00	24.05
10.20	6.80	5.30
17.00	18.00	15.00
289.40	179.27	147.14
306.40	197.27	162.14
379.30	227.10	182.40

SILVER CREEK

Date	8/8/72	9/19/72	10/8/72	11/3/72
Flow	42.23	7.18	7.22	6.13
HCO_3^-	29.36	75.80	77.46	76.35
Cl^-	.50	1.35	1.12	1.05
$SO_4^=$	2.70	7.70	7.68	7.80
Na^+	2.60	5.80	6.50	6.50
K^+	.70	1.20	.60	1.20
Ca^{++}	6.20	16.50	16.60	15.70
Mg^{++}	1.40	3.90	3.45	3.60
SiO_2	9.10	39.00	23.70	23.00
TDS without SiO_2	43.66	112.25	113.41	112.20
TDS with SiO_2	52.76	151.25	137.11	135.20
Specific Conductance	48.00	138.00	131.60	138.00

4/5/73	4/19/73	6/26/73
22.31	61.22	83.77
87.74	74.84	35.30
.50	.46	.26
6.60	5.80	2.90
6.30	5.60	3.25
1.16	1.00	.80
20.10	16.20	6.55
3.80	3.40	1.70
19.50	17.00	18.00
126.20	107.30	50.70
145.70	124.30	68.70
150.60	126.30	60.51

WOLF CREEK

Date	8/8/72	9/10/72	10/8/72	11/3/72
Flow	11.06	12.96	12.85	5.76
HCO^-_3	60.45	52.50	52.42	51.46
Cl^-	.70	.45	.47	.46
$SO_4^=$	.50	.50	.50	.50
Na^+	3.65	3.10	3.00	3.30
K^+	2.80	1.80	2.50	1.90
Ca^{++}	10.10	8.60	8.70	8.00
Mg^{++}	3.90	3.60	3.00	3.40
SiO_2	34.30	54.25	31.00	31.00
TDS without SiO_2	82.10	70.55	70.59	69.02
TDS with SiO_2	116.40	124.80	101.59	100.02
Specific Conductance	95.10	85.01	81.79	79.68

6/19/73	6/26/73
96.50	76.76
35.30	30.60
.21	.10
.50	.50
2.25	2.05
1.40	1.25
5.50	4.65
2.10	1.85
24.50	25.00
47.26	41.00
71.76	66.00
57.92	50.64

EAST FORK CARSON RIVER

Date	8/12/72	9/14/72	10/12/72	11/7/72
Flow	17.68	13.68	14.40	15.78
HCO_3^-	52.16	55.16	51.89	51.10
Cl^-	4.35	4.65	4.20	4.72
$SO_4^=$	.50	.50	.50	.50
Na^+	10.60	10.40	10.75	11.60
K^+	1.30	1.00	.90	1.06
Ca^{++}	6.90	7.60	7.40	7.00
Mg^{++}	1.70	2.00	1.60	1.70
SiO_2	18.60	31.25	20.00	18.75
TDS without SiO_2	77.51	81.31	77.24	77.68
TDS with SiO_2	96.11	112.56	97.24	96.43
Specific Conductance	89.10	100.70	96.71	94.04

6/21/73	6/28/73
178.83	172.27
18.34	16.50
.45	.53
.50	.50
2.60	2.65
.42	.38
2.75	2.50
.65	.62
11.25	11.70
25.71	23.68
36.93	35.38
29.52	28.32

SILVER KING CREEK

Date	8/12/72	9/14/72	10/12/72	11/7/72
Flow	13.60	11.44	11.29	9.33
HCO_3^-	41.45	45.72	48.09	49.07
Cl^-	4.35	4.45	4.00	4.45
$SO_4^=$	.50	.50	.50	2.40
Na^+	8.80	9.78	9.80	10.20
K^+	.80	.86	.80	.98
Ca^{++}	5.90	6.20	6.40	6.40
Mg^{++}	1.60	2.00	1.50	1.90
SiO_2	17.70	30.00	19.75	20.50
TDS without SiO_2	63.40	69.51	71.09	75.40
TDS with SiO_2	81.10	99.51	90.84	95.90
Specific Conductance	76.20	86.35	86.17	88.04

6/21/73	6/28/73
82.46	77.13
24.45	22.40
.95	1.03
.50	.50
3.60	3.75
.40	.35
3.75	3.30
.85	.83
14.50	13.50
34.50	32.19
49.00	45.69
41.05	42.93

APPENDIX III

VALUES OF K, n, AND CORRELATION COEFFICIENTS FOR FLOW-CONCENTRATION EQUATION

$$C=KQ^{-n}$$

K-Intercept values

BASIN	HCO_3^-	Cl^-	$SO_4^{=}$	Na^+	K^+	Ca^{++}	Mg^{++}
Mott Canyon Creek	51.24	.42	.50	5.03	3.34	9.06	1.58
Fredericksburg Can. Cr.	45.28	.69	7.05	5.58	1.68	8.45	1.71
Deep Canyon Creek	41.82	.45	.50	2.55	1.78	5.37	3.55
Horsethief Canyon Creek	52.70	.48	2.11	4.54	1.95	8.21	3.24
Willow Creek	62.68	1.25	. 3	6.67	1.54	11.91	2.85
Red Lakes Creek	58.63	.69	9.33	3.39	.84	15.31	2.86
W. Fork Carson River	36.72	.65	4.48	2.75	.51	8.11	1.98
Hot Springs Creek	60.29	2.78	3.29	6.87	.89	10.97	2.80
Spratt Creek	78.35	.44	.93	5.11	.80	15.12	3.72
Pleasant Valley Creek	138.24	.62	13.38	8.72	1.21	33.37	7.24
Indian Creek	105.95	.61	108.98	10.64	1.27	59.76	11.59
Silver Creek	126.84	3.45	14.77	9.88	1.10	28.62	6.03
Wolf Creek	86.66	1.67	.50	4.93	3.51	14.70	5.98
E. Fork Carson River	180.00	52.64	.50	52.23	3.04	22.38	5.39
Silver King Creek	106.65	26.04	1.43	31.75	2.40	12.56	4.29

K-Intercept values continued

BASIN	SiO_2	TDS W/O SiO_2	TDS WITH SiO_2
Mott Canyon Creek	18.46	69.12	87.59
Fredericksburg Can. Cr.	26.13	67.66	94.20
Deep Canyon Creek	27.65	56.07	83.82
Horsethief Canyon Creek	32.54	73.29	106.12
Willow Creek	34.96	82.95	117.58
Red Lakes Creek	19.45	91.15	110.69
W. Fork Carson River	9.95	54.72	64.52
Hot Springs Creek	20.85	87.51	108.55
Spratt Creek	19.50	105.95	124.59
Pleasant Valley Creek	31.38	202.64	234.42
Indian Creek	18.71	322.97	343.42
Silver Creek	43.80	189.33	233.22
Wolf Creek	50.23	117.34	189.30
E. Fork Carson River	44.92	284.00	314.58
Silver King Creek	36.88	174.68	208.35

SPECIFIC CONDUCTANCE
81.42
75.62
64.51
84.83
99.05
113.11
68.17
103.11
120.23
249.43
393.95
240.92
129.78
359.40
199.40

n-Regression slope values

BASIN	HCO_3^-	Cl^-	$SO_4^=$
Mott Canyon Creek	.05	.40	0.0
Fredericksburg Can. Cr.	.19	.48	1.22
Deep Canyon Creek	.10	.13	0.0
Horsethief Canyon Creek	.17	.41	1.11
Willow Creek	.38	.60	-.64
Red Lakes Creek	.17	.24	.32
W. Fork Carson River	.16	.18	.52
Hot Springs Creek	.22	.55	.38
Spratt Creek	.23	.19	.13
Pleasant Valley Creek	.26	.20	.36
Indian Creek	.03	.27	.58
Silver Creek	.24	.57	.33
Wolf Creek	.21	.53	0.0
E. Fork Carson River	.45	.90	0.0
Silver King Creek	.35	.74	.26

Na^{+}	K^{+}	Ca^{++}	Mg^{++}
.20	-.19	.01	-.03
.37	.12	.26	.11
.15	.04	.10	.12
.23	.21	.22	.25
.35	.19	.44	.46
.19	.01	.22	.15
.18	.14	.19	.18
.28	.20	.22	.19
.25	.16	.22	.21
.28	.16	.30	.28
.30	.23	.37	.33
.23	.06	.27	.25
.18	.21	.23	.24
.58	.39	.41	.41
.49	.42	.29	.37

n-Regression slope values continued

BASIN	SiO_2	TDS W/O SiO_2	TDS WITH SiO_2
Mott Canyon Creek	-.02	.05	.03
Fredericksburg Can. Cr.	.14	.24	.21
Deep Canyon Creek	.04	.10	.08
Horsethief Canyon Creek	.17	.20	.19
Willow Creek	.29	.34	.32
Red Lakes Creek	.16	.19	.18
W. Fork Carson River	.05	.18	.15
Hot Springs Creek	.18	.23	.22
Spratt Creek	.16	.22	.21
Pleasant Valley Creek	.25	.27	.27
Indian Creek	.12	.33	.32
Silver Creek	.26	.25	.25
Wolf Creek	.15	.21	.19
E. Fork Carson River	.27	.47	.42
Silver King Creek	.22	.38	.34

SPECIFIC CONDUCTANCE
.04
.21
.09
.20
.36
.20
.21
.24
.21
.29
.31
.28
.19
.49
.36

Correlation Coefficients-all values negative except positive values denoted by "*"

BASIN	HCO_3^-	Cl^-	$SO_4^=$	Na^+
Mott Canyon Creek	.592	.317	0.0	.614
Fredericksburg Can. Cr.	.918	.547	.909	.934
Deep Canyon Creek	.863	.581	0.0	.872
Horsethief Canyon Creek	.814	.475	.636	.866
Willow Creek	.967	.974	*.692	.951
Red Lakes Creek	.955	.605	.957	.953
W. Fork Carson River	.964	.647	.936	.898
Hot Springs Creek	.989	.991	.898	.989
Spratt Creek	.888	.672	.311	.882
Pleasant Valley Creek	.945	.499	.772	.959
Indian Creek	.362	.946	.993	.986
Silver Creek	.613	.935	.812	.677
Wolf Creek	.901	.853	0.0	.926
E. Fork Carson River	.996	.997	0.0	.995
Silver King Creek	.992	.993	.407	.999

K^+	Ca^{++}	Mg^{++}
*.320	.108	* .212
.570	.966	.586
.398	.805	.926
.458	.895	.762
.868	.968	.974
.089	.970	.872
.539	.958	.960
.739	.981	.961
.878	.890	.919
.630	.926	.945
.920	.995	.994
.233	.608	.652
.759	.873	.910
.954	.998	.991
.989	.986	.970

Correlation Coefficients continued

BASIN	SiO_2	TDS W/O SiO_2	TDS WITH SiO_2
Mott Canyon Creek	*.131	.553	.389
Fredericksburg Can. Cr.	.348	.955	.803
Deep Canyon Creek	.635	.877	.870
Horsethief Canyon Creek	.460	.895	.777
Willow Creek	.964	.970	.976
Red Lakes Creek	.939	.961	.970
W. Fork Carson River	.454	.973	.980
Hot Springs Creek	.865	.990	.984
Spratt Creek	.865	.894	.907
Pleasant Valley Creek	.805	.943	.955
Indian Creek	.756	.998	.999
Silver Creek	.668	.637	.666
Wolf Creek	.586	.897	.853
E. Fork Carson River	.886	.997	.996
Silver King Creek	.787	.996	.987

SPECIFIC CONDUCTANCE
.236
.970
.894
.858
.967
.978
.963
.987
.898
.911
.993
.698
.881
.999
.997

APPENDIX IV
CONSTANTS AND CORRELATION COEFFICIENTS FOR
SPECIFIC CONDUCTANCE-CONCENTRATION RELATION
$C=A+\overline{B}x(S.C.)$

Constant-"A"

BASIN	HCO_3^-	Cl^-	$SO_4^=$	Na^{++}	K^+	Ca^{++}	Mg^{++}
Mott Canyon Creek	36.47	.23	.50	1.33	2.40	5.32	2.28
Fredericksburg Can. Cr.	-.44	-.67	-5.93	-2.91	.49	-1.75	.53
Deep Canyon Creek	-6.88	.03	.50	-1.06	.90	-.98	-.56
Horsethief Canyon Creek	3.92	.33	-.78	.80	-.37	.21	-.98
Willow Creek	-.71	-.17	4.01	.74	.64	-.99	-.20
Red Lakes Creek	3.84	-.12	-3.45	.17	.78	-1.32	.52
W. Fork Carson River	4.68	.19	-1.80	.52	.05	.14	.21
Hot Springs Creek	2.61	-1.02	-.29	-.45	-.01	.50	.37
Spratt Creek	-4.72	.15	.90	-.56	.20	-.62	-.04
Pleasant Valley Creek	7.62	.25	-1.73	.40	.37	-.45	.16
Indian Creek	100.97	.13	-122.68	-.81	.30	-14.36	-1.68
Silver Creek	2.34	.06	.31	.88	.52	-.62	.21
Wolf Creek	-3.45	-.52	.50	.24	-.40	-1.54	-.60
E. Fork Carson River	2.31	-1.21	.50	-.83	.14	.62	.14
Silver King Creek	.82	-2.12	-.15	-2.18	-.10	.91	-.06

Constant-"A" continued

BASIN	SiO_2	TDS W/O SiO_2	TDS WITH SiO_2
Mott Canyon Creek	15.84	48.52	64.72
Fredericksburg Can. Cr.	.45	-10.69	-10.24
Deep Canyon Creek	15.17	-8.06	7.11
Horsethief Canyon Creek	-11.07	3.13	-7.94
Willow Creek	3.35	3.31	6.66
Red Lakes Creek	2.89	.62	3.51
W. Fork Carson River	7.41	4.00	11.41
Hot Springs Creek	.88	1.70	2.58
Spratt Creek	2.02	-4.68	-2.66
Pleasant Valley Creek	1.49	6.61	8.10
Indian Creek	8.82	-38.13	-29.31
Silver Cree-	6.05	3.70	9.75
Wolf Creek	4.72	-5.76	-1.04
E. Fork Carson River	6.07	1.68	7.74
Silver King Creek	5.38	-2.85	2.53

Constant-"B"

BASIN	HCO_3^-	Cl^-	$SO_4^=$
Mott Canyon Creek	.17	.001	0.0
Fredericksburg Can. Cr.	.62	.02	.13
Deep Canyon Creek	.75	.007	0.0
Horsethief Canyon Creek	.58	.001	.03
Willow Creek	.62	.01	-.05
Red Lakes Creek	.49	.01	.11
W. Fork Carson River	.48	.01	.08
Hot Springs Creek	.56	.03	.03
Spratt Creek	.69	.002	.001
Pleasant Valley Creek	.53	.001	.06
Indian Creek	.01	.001	.65
Silver Creek	.56	.01	.05
Wolf Creek	.67	.01	0.0
E. Fork Carson River	.53	.06	0.0
Silver King Creek	.54	.08	.01

Na^+	K^+	Ca^{++}	Mg^{++}
.04	-.01	.05	-.01
.11	.02	.14	.02
.06	.01	.10	.06
.04	.03	.09	.05
.05	.01	.12	.03
.03	.001	.15	.02
.03	.01	.12	.03
.07	.01	.10	.02
.05	.005	.13	.03
.03	.004	.13	.03
.03	.002	.19	.03
.04	.004	.13	.02
.04	.03	.12	.05
.12	.01	.07	.02
.14	.01	.06	.02

Constant-"B" continued

BASIN	SiO_2	TDS W/O SiO_2	TDS WITH SiO_2
Mott Canyon Creek	.04	.23	.27
Fredericksburg Can. Cr.	.38	1.05	1.43
Deep Canyon Creek	.19	.99	1.19
Horsethief Canyon Creek	.54	.82	1.36
Willow Creek	.34	.80	1.14
Red Lakes Creek	.15	.80	.95
W. Fork Carson River	.03	.74	.78
Hot Springs Creek	.21	.83	1.04
Spratt Creek	.15	.91	1.06
Pleasant Valley Creek	.13	.79	.91
Indian Creek	.02	.92	.95
Silver Creek	.13	.81	.94
Wolf Creek	.38	.92	1.30
E. Fork Carson River	.17	.81	.98
Silver King Creek	.20	.86	1.06

Na^+	K^+	Ca^{++}	Mg^{++}
.521	-.227	.824	-.634
.944	.584	.974	.622
.878	.388	.911	.911
.708	.557	.904	.914
.922	.765	.895	.982
.973	.098	.995	.926
.799	.499	.992	.898
.965	.869	.988	.975
.977	.864	.995	.989
.948	.637	.909	.942
.992	.843	.991	.987
.976	.623	.994	.953
.973	.879	.996	.977
.987	.896	.999	.983
.999	.376	.988	.946

Correlation Coefficient

BASIN	HCO_3^-	Cl^-	$SO_4^=$
Mott Canyon Creek	.690	.063	0.0
Fredericksburg Can. Cr.	.965	.451	.892
Deep Canyon Creek	.949	.391	0.0
Horsethief Canyon Creek	.991	.038	.252
Willow Creek	.992	.815	-.789
Red Lakes Creek	.989	.872	.958
W. Fork Carson River	.974	.437	.949
Hot Springs Creek	.995	.968	.895
Spratt Creek	.996	.462	.059
Pleasant Valley Creek	.981	.250	.877
Indian Creek	.221	.956	.988
Silver Creek	.995	.580	.934
Wolf Creek	.997	.981	0.0
E. Fork Carson River	.996	.992	0.0
Silver King Creek	.994	.977	.395

Na^+	K^+	Ca^{++}	Mg^{++}
.521	-.227	.824	-.634
.944	.584	.974	.622
.878	.388	.911	.911
.708	.557	.904	.914
.922	.765	.995	.982
.975	.098	.995	.926
.799	.499	.992	.898
.985	.869	.988	.975
.977	.864	.995	.989
.948	.637	.989	.943
.982	.843	.991	.987
.976	.623	.984	.993
.973	.879	.996	.977
.987	.896	.999	.983
.999	.975	.988	.946

Correlation Coefficient continued

BASIN	SiO_2	TDS W/O SiO_2	TDS WITH SiO_2
MottCanyon Creek	.259	.713	.648
Fredericksburg Can. Cr.	.375	.984	.809
Deep Canyon Creek	.755	.953	.970
Horsethief Canyon Creek	.736	.969	.960
Willow Creek	.981	.991	.994
Red Lakes Creek	.925	.995	.997
W. Fork Carson River	.262	.976	.954
Hot Springs Creek	.866	.996	.994
Spratt Creek	.837	.997	.998
Pleasant Valley Creek	.713	.990	.980
Indian Creek	.785	.997	.997
Silver Creek	.606	.997	.988
Wolf Creek	.596	.997	.944
E. Fork Carson River	.812	.997	.993
Silver King Creek	.745	.995	.990

N DISSOLVED IONS

		CATIONS	
Na^{+}	K^{+}	Ca^{++}	Mg^{++}
.223	.049	.552	.169
.249	.060	.494	.197
.153	.066	.375	.406
.214	.055	.446	.285
.284	.056	.477	.184
.128	.027	.628	.218
.173	.022	.569	.236
.249	.022	.501	.227
.167	.017	.578	.238
.145	.017	.604	.234
.163	.007	.627	.213
.194	.022	.574	.210
.166	.052	.473	.306
.497	.029	.321	.152
.441	.024	.373	.163

APPENDIX V
AVERAGE IONIC RATIOS FOR SEVEN DISSOLVED IONS

	ANIONS			CATIONS			
BASIN	HCO_3^-	Cl^-	$SO_4^=$	Na^+	K^+	Ca^{++}	Mg^{++}
Mott Canyon Creek	.976	.011	.012	.223	.049	.552	.164
Fredericksburg Can. Cr.	.924	.018	.058	.249	.060	.494	.197
Deep Canyon Creek	.966	.018	.016	.153	.066	.375	.406
Horsethief Canyon Creek	.955	.012	.032	.214	.055	.446	.285
Willow Creek	.915	.020	.065	.284	.056	.477	.184
Red Lakes Creek	.844	.017	.139	.128	.027	.628	.218
W. Fork Carson River	.911	.028	.060	.173	.022	.569	.236
Hot Springs Creek	.907	.043	.050	.249	.022	.501	.227
Spratt Creek	.972	.010	.020	.167	.017	.578	.238
Pleasant Valley Creek	.905	.009	.085	.145	.017	.604	.234
Indian Creek	.394	.004	.602	.103	.007	.677	.213
Silver Creek	.881	.017	.102	.194	.022	.574	.210
Wolf Creek	.973	.013	.014	.160	.062	.473	.305
E. Fork Carson River	.882	.099	.018	.437	.029	.381	.152
Silver King Creek	.864	.113	.023	.441	.024	.373	.163

APPENDIX VI

Basin Characteristics

Key to Characteristic Table With Descriptions
Units in Parenthesis

Characteristic Number

1) Area (square miles)	each sub-basin was outlined on a U.S.G.S. 15 minute series topographic map and enclosed area measured with a planimeter.
2) Maximum Elevation (feet)	highest point in basin usually on basin boundary.
3) Minimum Elevation (feet)	lowest point in basin usually the sampling site.
4) Median Elevation (feet)	determined from an elevation area curve as the elevation at the 50% area intersection.
5) Total Relief (feet)	difference between maximum and minimum elevation.
6) % Area above 8000' Elevation (dimensionless)	measured with a plaimeter and converted to percent of total area.
7) Relief Ratio (feet/mile)	total relief divided by distance from outlet to furtherest point on the basin boundary, the maximum basin length.
8) Ruggedness Number (dimensionless)	total relief in miles times drainage density.
9) Average Overland Slope (feet/mile)	determined by equation $S = \frac{1.57hN}{L_g}$ where S = average overland slope (ft/mile) h = contour interval (feet) N = number of intersection of contour lines with grid placed over basin map

		L_g = length of grid lines in basin (miles)
10)	Stream Order (dimensionless)	a) smallest tributaries are I b) where two number 1's join a 2 is formed c) where two number 2's join a 3 is formed, etc. d) the stream at the outlet has the highest order.
11)	Main Channel Slope (feet/mile)	total length of main channel divided by total change in elevation from head to outlet.
12)	Total Channel Length (miles)	total length of all streams in basin measured from U.S.G.A. topographic maps with an opsiometer.
13)	Drainage Density (1/mile)	Total channel length divided by basin area.
14)	Texture Ratio (1/mile)	number of crenulations or V notches on median elevation contour divided by length of perimeter.
15)	Length of Overland Flow (miles)	one-half the recipricol of the drainage density.
16)	Stream Frequency (1/square mile)	total number of streams divided by basin area.
17)	Coefficient of Channel Maintenance (miles)	recipricol of drainage density.
18)	Hypsometric Integral (dimensionless)	dimensionless area under area - elevation curve.
19)	Perimeter (miles)	basin perimeter measured on a U.S.G.S. topographic map with an opsiometer.
20)	Form Factor (dimensionless)	area divided by square of maximum basin length.

21)	Circularity Ratio (dimensionless)	ratio of basin area to area of circle having same perimeter length as basin.
22)	Elongation Ratio (dimensionless)	diameter of circle with same area as basin divided by maximum basin length.
23)	Average Effective Basin Width (miles)	basin area divided by length of mainstream to basin divide.
24)	Compactness Coefficient (dimensionless)	ratio of basin perimeter to perimeter of circle with same area as basin.
25)	Percent basin Covered by Entisols	
26)	Percent Basin Covered by Inceptisols	
27)	Percent Basin Covered by Mollisols (all dimensionless)	Areas measured with planimeter from enlargement of USDA - SCS soils map and converted to percent area.
28)	Box Coefficient (dimensionless)	length of median elevation divided by basin perimeter.
29)	Percent Area Granitics	
30)	Percent Area Volcanics (both dimensionless)	planimetered from enlargement of California Division of Mines and Geology Walker Lake AMS geologic map and converted to percent area.
31)	Average Permeability	(infiltration rate in./hr)
32)	Average Runoff Potential	(dimensionless)
33)	Average Available Water Capacity	(inches)
34)	Average Soil Depth (inches)	all measures calculated on percent area weighted average of soil types in basin from USDA - SCS soils map and soils characteristics description

35)	Percent by Weight Na^+ in basin	
36)	Percent by Weight K^+ in basin	
37)	Percent by Weight Ca^{++} in basin	
38)	Percent by Weight Mg^{++} in basin	
39)	Percent by Weight SiO_2 in basin (all dimensionless)	all calculated on percent area weighted averag of igneous rock types from geologic map and percent ionic composition from several sources.
40)	Percent area Metamorphics	
41)	Percent area Alluvial Materials	
42)	Percent Area Glacial Materials	calculated same as 29 and 30 above.
43)	Percent Total Stream-length in Granitics	
44)	Percent Total Stream-length in Volcanics	
45)	Percent Total Stream-length in Metamorphics	
46)	Percent Total Stream-length in Alluvial Material	
47)	Percent Total Stream-length in Glacial Material	
48)	Percent Total Stream-length in Entisols	
49)	Percent Total Stream-length in Inceptisols	

50)	Percent Total Stream-length in Mollisols (all dimensionless)	length of streams in each unit measured and converted to percent of total.
51)	Miles of Roadway per Square Mile of Basin (1/mile)	all roadways measured from topographic maps and divided by basin area.
52)	Percent Relief Median Elevation (dimensionless)	from area-elevation curve.
53)	High Flow	as measured.
54)	Low Flow	as measured.
55)	Flow Range	difference between high and low flow.
56)	Flow Variation Factor	ratio of high to low flow.
57)	Ratio of Low Flow to Area	
58)	Ratio of Low Flow to Area Times Main Channel Slope	
59)	Ratio of Low Flow to Main Channel Length	
60)	Ratio of Low Flow to Area time Channel Slope	
61)	Ratio of Low Flow to Area Drainage Density	characteristics 53 through 61 are self-explanatory.

62) Mining Activity Coefficient (dimensionless) — ranking of ratio of mines plus prospects in a basin, as delineated from topographic maps and field inspection, to basin area.

(Mines + Prospects)/Basin Area	M.A.C.
0 - .05	1
.15 - .25	2
.26 - .50	3

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63) Ratio of Percent North Aspect of Percent South Aspect

64) Ratio of Percent East Aspect to Percent West Aspect

65) Percent Non-Sloping Area (dimensionless) — characteristics 63 through 65 are measured by placing a grid on a topographic map of the basin and counting the compass directions of slopes under grid node points, no slope is also noted. Individual totals are then converted to percentage total counts.

APPENDIX VI
PHYSIOGRAPHIC BASIN CHARACTERISTICS
(CHARACTERISTICS KEYED TO PREVIOUS DESCRIPTIONS)

BASIN	CHARACTERISTIC NUMBER 1	2	3	4	5	6	7
Mott Canyon Creek	2.12	10067	4880	7691	5187	44.30	.30
Fredericksburg Can. Cr.	3.60	9850	5420	8521	4430	61.10	.21
Deep Canyon Creek	1.61	9520	6360	8382	3160	73.90	.30
Horsethief Canyon Creek	3.26	9370	6640	8196	2730	71.20	.17
Willow Creek	10.82	10881	7060	8573	3821	76.90	.12
Red Lakes Creek	8.90	10061	7160	7905	2801	44.70	.12
W. Fork Carson River	13.84	9770	7160	7917	2610	41.30	.08
Hot Springs Creek	14.57	10023	5880	8171	4143	61.30	.13
Spratt Creek	4.80	9280	5680	7600	3600	26.50	.13
Pleasant Valley Creek	24.28	10011	5800	7956	4211	42.80	.10
Indian Creek	6.22	8448	5494	7009	2954	6.40	.12
Silver Creek	30.62	10934	5910	8171	5024	58.50	.12
Wolf Creek	29.10	10934	6360	8386	4574	66.30	.09
E. Fork Carson River	47.52	11462	6460	8556	5002	69.30	.07
Silver King Creek	40.06	10970	6620	8634	4350	81.80	.08

BASIN	8	9
Mott Canyon Creek	1.30	2393
Fredericksburg Can. Cr.	.77	2224
Deep Canyon Creek	.63	2595
Horsethief Canyon Creek	.44	1903
Willow Creek	.75	1696
Red Lakes Creek	.59	1275
W. Fork Carson River	.63	1423
Hot Springs Creek	1.08	1731
Spratt Creek	.74	1642
Pleasant Valley Creek	1.03	1138
Indian Creek	.79	1710
Silver Creek	1.19	2012
Wolf Creek	.84	2107
E. Fork Carson River	1.06	2143
Silver King Creek	.82	1698

CHARACTERISTIC NUMBER

10	11	12	13	14
1	1257	2.80	1.32	.649
1	879	3.30	.92	1.132
1	1141	1.70	1.06	1.667
1	557	2.80	.86	1.026
2	352	11.30	1.04	1.806
2	302	9.90	1.11	1.406
3	213	17.60	1.27	.942
3	341	20.10	1.38	2.670
1	454	5.20	1.08	.615
3	260	31.40	1.29	2.520
2	610	8.80	1.41	1.681
4	311	38.30	1.25	2.374
3	239	28.10	.97	3.654
3	186	53.40	1.12	2.302
3	233	39.90	1.00	.671

CHARACTERISTIC NUMBER

BASIN	15	16	17	18	19	20	21
Mott Canyon Creek	.38	.47	.76	.526	7.70	.20	.449
Fredericksburg Can. Cr.	.54	.28	1.09	.637	10.60	.22	.403
Deep Canyon Creek	.48	.62	.95	.612	5.40	.40	.694
Horsethief Canyon Creek	.58	.31	1.16	.584	7.80	.33	.566
Willow Creek	.48	.37	.96	.408	15.50	.30	.566
Red Lakes Creek	.45	.45	.90	.340	12.80	.42	.683
W. Fork Carson River	.40	.65	.79	.316	19.10	.33	.477
Hot Springs Creek	.36	.55	.72	.537	19.50	.38	.482
Spratt Creek	.46	.21	.92	.456	13.00	.18	.357
Pleasant Valley Creek	.38	.49	.77	.454	25.40	.41	.473
Indian Creek	.36	.64	.71	.515	11.30	.31	.612
Silver Creek	.40	.33	.80	.436	25.70	.46	.583
Wolf Creek	.52	.34	1.03	.436	26.00	.31	.539
E. Fork Carson River	.44	.38	.89	.422	41.70	.23	.343
Silver King Creek	.50	.27	1.00	.492	31.30	.34	.514

BASIN	22	23
Mott Canyon Creek	.51	.61
Fredericksburg Can. Cr.	.52	.86
Deep Canyon Creek	.72	.73
Horsethief Canyon Creek	.65	1.16
Willow Creek	.62	1.59
Red Lakes Creek	.73	1.65
W. Fork Carson River	.65	1.87
Hot Springs Creek	.69	1.87
Spratt Creek	.48	.85
Pleasant Valley Creek	.72	2.73
Indian Creek	.63	1.27
Silver Creek	.77	3.44
Wolf Creek	.63	3.09
E. Fork Carson River	.54	2.61
Silver King Creek	.66	3.11

CHARACTERISTIC NUMBER

24	25	26	27	28
1.48	100.0	0.00	0.00	.169
1.56	40.30	59.70	0.00	.292
1.19	9.90	89.40	.70	.426
1.21	42.90	57.10	0.00	.564
1.32	86.20	0.00	13.80	.542
1.20	9.30	79.70	11.00	.547
1.44	0.00	93.00	7.00	.414
1.43	25.90	71.80	12.30	.821
1.66	19.80	52.00	18.20	.185
1.44	32.20	54.20	13.20	.724
1.27	0.00	59.60	39.10	.354
1.36	40.80	47.70	32.30	.914
1.35	20.40	79.40	0.00	.965
1.69	58.00	40.80	1.20	.803
1.38	43.20	40.80	17.00	.770

BASIN	29	30
Mott Canyon Creek	97.60	0.00
Fredericksburg Can. Cr.	45.00	20.00
Deep Canyon Creek	24.80	75.20
Horsethief Canyon Creek	85.90	14.10
Willow Creek	99.30	0.00
Red Lakes Creek	27.00	39.40
W. Fork Carson River	55.50	40.70
Hot Springs Creek	56.10	37.30
Spratt Creek	52.40	45.40
Pleasant Valley Creek	50.90	45.70
Indian Creek	0.00	100.0
Silver Creek	32.40	65.10
Wolf Creek	30.50	68.20
E. Fork Carson River	70.30	23.70
Silver King Creek	65.50	25.10

CHARACTERISTIC NUMBER

31	32	33	34	35
.16	3.75	.64	24.00	2.60
2.56	2.40	1.15	47.00	2.70
3.74	2.11	1.23	43.00	2.60
2.46	2.43	1.14	39.00	2.70
.73	3.34	.84	29.00	2.60
3.06	3.65	.83	35.00	2.60
2.63	3.73	.82	33.00	2.70
1.51	3.81	.73	29.00	2.70
1.99	3.51	.98	33.00	2.70
1.34	4.13	.51	26.00	2.70
1.56	2.78	1.05	48,00	2.60
.41	4.32	.46	23.00	2.60
1.27	4.32	.36	24.00	2.60
1.67	4.14	.52	27.00	2.70
1.83	3.34	.89	27.00	2.70

CHARACTERISTIC NUMBER

BASIN	36	37	38	39	40	41	42
Mott Canyon Creek	2.50	2.40	.80	31.30	0.00	2.40	0.00
Fredericksburg Can. Cr.	2.30	3.20	1.20	29.90	35.00	0.00	0.00
Deep Canyon Creek	1.90	4.40	1.70	27.80	0.00	0.00	0.00
Horsethief Canyon Creek	2.40	2.80	1.00	30.60	0.00	0.00	0.00
Willow Creek	2.50	2.40	.80	31.30	0.00	.70	0.00
Red Lakes Creek	2.00	3.90	1.50	28.50	23.80	3.50	6.00
W. Fork Carson River	2.20	3.50	1.30	29.30	1.80	2.00	0.00
Hot Springs Creek	2.20	3.40	1.30	29.40	2.30	3.80	0.00
Spratt Creek	2.10	3.60	1.40	29.20	0.00	0.00	2.10
Pleasant Valley Creek	2.10	3.60	1.40	29.10	0.00	2.70	.70
Indian Creek	1.70	5.00	2.00	26.60	0.00	0.00	0.00
Silver Creek	2.00	4.10	1.60	28.20	0.00	1.20	1.20
Wolf Creek	1.90	4.20	1.60	28.10	0.00	1.20	0.00
E. Fork Carson River	2.30	3.10	1.10	30.10	0.00	2.80	.10
Silver King Creek	2.30	3.10	1.20	30.00	4.00	1.50	1.20

BASIN	43	44
Mott Canyon Creek	82.10	0.00
Fredericksburg Can. Cr.	33.30	0.00
Deep Canyon Creek	70.60	29.40
Horsethief Canyon Creek	82.10	17.90
Willow Creek	96.50	0.00
Red Lakes Creek	28.30	28.30
W. Fork Carson River	63.60	30.70
Hot Springs Creek	68.20	16.90
Spratt Creek	53.80	38.50
Pleasant Valley Creek	65.60	31.80
Indian Creek	0.00	100.0
Silver Creek	41.30	50.10
Wolf Creek	28.80	65.90
E. Fork Carson River	80.40	6.90
Silver King Creek	77.90	7.30

CHARACTERISTIC NUMBER

45	46	47	48	49
0.00	17.90	0.00	100.0	0.00
66.70	0.00	0.00	0.00	100.00
0.00	0.00	0.00	29.40	70.60
0.00	00.00	0.00	50.00	50.00
0.00	3.50	0.00	82.30	17.70
21.20	8.10	11.10	0.00	69.70
0.00	7.40	0.00	0.00	96.00
2.00	12.90	0.00	16.90	72.60
0.00	0.00	7.70	15.40	57.70
0.00	1.60	1.00	22.00	56.20
0.00	0.00	0.00	0.00	53.40
0.00	5.20	3.40	42.30	41.20
0.00	5.30	0.00	27.80	72.20
0.00	11.60	0.00	73.60	25.30
4.00	6.00	3.30	45.90	45.40

BASIN	50	51
Mott Canyon Creek	0.00	.472
Fredericksburg Can. Cr.	0.00	.417
Deep Canyon Creek	0.00	0.00
Horsethief Canyon Creek	0.00	0.00
Willow Creek	0.00	.092
Red Lakes Creek	30.00	1.030
W. Fork Carson River	4.00	.361
Hot Springs Creek	10.50	.268
Spratt Creek	26.90	.479
Pleasant Valley Creek	11.80	.194
Indian Creek	46.60	.209
Silver Creek	16.50	.372
Wolf Creek	0.00	1.00
E. Fork Carson River	1.10	0.00
Silver King Creek	8.70	.012

CHARACTERISTIC NUMBER

52	53	54	55	56
54.20	3.01	1.33	1.68	2.26
70.00	9.50	2.14	7.36	4.44
64.00	15.86	.44	15.42	36.00
57.00	4.12	1.16	2.96	3.55
39.60	41.51	2.93	38.58	14.17
6.60	80.08	.996	79.08	80.40
29.00	145.5	3.61	141.9	40.31
55.30	168.3	.895	167.4	188.0
53.30	35.78	.280	35.50	127.8
51.20	62.71	5.46	57.25	11.49
51.30	9.63	.07	9.56	137.6
45.00	93.65	6.13	87.52	15.28
44.30	96.50	5.76	90.74	16.75
41.90	178.8	13.68	165.2	13.07
46.30	82.46	9.33	73.13	8.84

CHARACTERISTIC NUMBER

BASIN	57	58	59	60	61	62	63
Mott Canyon Creek	.63	2.65	.48	2.02	1.01	1	1.007
Fredericksburg Can. Cr.	.59	3.54	.65	3.90	2.33	1	1.203
Deep Canyon Creek	.27	1.25	.26	1.20	.42	1	27.50
Horsethief Canyon Creek	.36	3.41	.41	3.89	1.35	1	0.00
Willow Creek	.27	4.05	.26	3.90	2.82	1	.075
Red Lakes Creek	.44	1.92	.10	1.75	.90	2	1.688
W. Fork Carson River	.26	6.45	.21	5.21	2.84	1	3.841
Hot Springs Creek	.06	.93	.04	.62	.65	1	1.040
Spratt Creek	.06	.70	.05	.58	.26	1	1.057
Pleasant Valley Creek	.22	4.47	.17	3.45	4.23	1	1.962
Indian Creek	.01	.09	.01	.07	.05	3	7.600
Silver Creek	.21	3.57	.16	2.72	4.90	2	2.168
Wolf Creek	.20	4.42	.20	4.42	5.94	1	1.551
E. Fork Carson River	.29	8.26	.26	7.38	12.21	1	1.808
Silver King Creek	.23	5.21	.23	5.21	9.33	1	3.073

BASIN	CHARACTERISTIC NUMBER 64	65
Mott Canyon Creek	75.00	.008
Fredericksburg Can. Cr.	20.67	.122
Deep Canyon Creek	3.375	0.00
Horsethief Canyon Creek	.696	.101
Willow Creek	.415	.126
Red Lakes Creek	5.562	.199
W. Fork Carson River	.776	.278
Hot Springs Creek	2.240	.164
Spratt Creek	11.30	.092
Pleasant Valley Creek	1.470	.147
Indian Creek	1.198	.056
Silver Creek	.962	.021
Wolf Creek	1.755	.055
E. Fork Carson River	1.042	.063
Silver King Creek	.787	.072

quations
Ionic Ratios

nt	F-Value	
	5.09	R^2 - .8509
	55.72	S.E.E. - 17.14
	.89	Mean - 18.14
	8.11	
17		
	23.33	R^2 - .8043
7	3.87	S.E.E. - .06
06	1.28	Mean - .28
5	2.10	
19	4.37	
13		
15	5.69	R^2 - .9394
24	6.24	S.E.E. - .04
17	6.47	Mean - .88
31	9.81	
31	111.47	

APPENDIX VII

Multiple Regression Equations For Intercept, Slope, and Ionic Ratios

HCO_3^- Values

	Variable	Coefficient	F-Value	
Intercept =	Constant	204.94		
	Median Elev.	-.0277	5.09	R^2 - .8908
	Total Channel Length	2.882	55.72	S.E.E. - 17.14
	Hypsometric Integral	49.229	.59	Mean - 18.14
	Avg. Soil Depth	1.592	3.11	
	% Stream Length in Inceptisols			
Slope =	Constant	-.63927		
	Relief Ratio	1.584	23.33	R^2 - .8043
	% Area Inceptisols	.0017	3.87	S.E.E. - .06
	% Area Volcanics	.00146	1.28	Mean - .22
	MAC	.0622	2.10	
	% N. Aspect/ % S. Aspect	-.00895	4.31	
Ionic Ratio =	Constant	2.01293		
	Stream Frequency	-.21455	5.63	R^2 - .9394
	Form Factor	.37664	6.24	S.E.E. - .04
	% by Weight Na^+	-.66647	6.41	Mean - .88
	RD/A	.14161	9.81	
	MAC	-.25881	111.47	

Cl^- Values

		Variable
Intercept	=	Constant
		Total Channel Length
		Elongation Ratio
		% by Weight Na^+
		% North Aspect/% South Aspect
Slope	=	Constant
		Relief Ratio
		% Area Inceptisols
		% Area Volcanics
		% Stream Length in Alluvium
		RD/A
Ionic Ratio	=	Constant
		Texture Ratio
		Stream Frequency
		% by Weight Na^+
		% Area Alluvium
		RD/A

Coefficient	F-Value		
-173.95	45.08	R^2 -	.8683
1.048	6.44	S.E.E. -	6.51
-159.748	16.42	Mean -	6.19
80.72	3.51		
.562	3.79		
-.77682			
1.213	3.48		
.00198	.81		
.00130	.35	R^2 -	.6167
-.0149	2.39	S.E.E. -	.18
.356	.91	Mean -	.43
.10699			
-.01614	2.84		
-.08267	2.53		
-.00776	.0023	R^2 -	.6266
.01952	8.40	S.E.E. -	.02
-.08946	7.82	Mean -	.03

$SO_4^{=}$

		Variable
Intercept	=	Constant
		Median Elev.
		Circularity Ratio
		Avg. Soil Depth
		RD/A
		MAC
Slopes	=	Constant
		Minimum Elev.
		Texture Ratio
		% Area Inceptisols
		Avg. Avail. Water Capacity
		% N. Aspect/% South Aspect
Ionic Ratio	=	Constant
		Minimum Elev.
		Form Factor
		RD/A
		MAC
		% Non-Sloping Area

Coefficient	F-Value		
128.54			
-.0189	9.47	R^2 -	.9553
-42.768	4.41	S.E.E. -	7.25
.67	6.88	Mean -	11.21
-37.591	23.16		
36.868	55.82		
-.83911			
.00028	4.71		
.0273	.04	R^2 -	.7019
-.01177	10.13	S.E.E. -	.31
-.91408	3.36	Mean -	.31
.04314	8.09		
.11128			
-.00005	5.53	R^2 -	.9559
-.29723	4.35	S.E.E. -	.04
-.21928	21.81	Mean -	.09
.27290	175.39		
.74922	15.97		

Na^+ Values

		Variable	Coefficient
Intercept	=	Constant	-4.94
		Total Channel Length	.97
		Elongation Ratio	-35.135
		Avg. Soil Depth	1.178
		MAC	-4.547
Slope	=	Constant	- .5718
		Relief Ratio	.96233
		Form Factor	.30643
		% Area Inceptisols	.00172
		Avg. Avail. Water Capacity	-.0916
		RD/A	.12125
Ionic Ratio	=	Constant	.60822
		Relief Ratio	-1.27604
		% Area Volcanics	-.00393
		RD/A	-.01405
		% N. Aspect/% South Aspect	.00861
		% Non-Sloping Area	-.75646

F-Value		
102.29	R^2	- .933
4.99	S.E.E.	- 4.35
23.71	Mean	- 10.71
3.36		
5.09		
.72	R^2	- .5559
2.19	S.E.E.	- .10
.59	Mean	- .28
1.49		
10.29	R^2	- .7832
18.84	S.E.E.	- .04
.03	Mean	- .22
3.96		
6.35		

K^+ Values

		Variable
Intercept	=	Constant
		Total Channel Length
		Drainage Density
		Texture Ratio
		RD/A
		% East Aspect/% West Aspect
Slopes	=	Constant
		Minimum Elev.
		Relief Ratio
		Avg. Avail. Water Capacity
		% Stream Length in Alluvium
		RD/A
Ionic Ratio	=	Constant
		Relief Ratio
		Texture Ratio
		Length of Overland Flow
		Stream Frequency
		% Area Volcanics

Coefficient	F-Value			
4.28				
.0187	4.69	R^2	-	.8215
-3.095	17.23	S.E.E.	-	.44
.384	5.80	Mean	-	1.59
-1.126	5.61			
.0179	6.22			
-.43284				
.00003	1.01			
1.94136	41.87	R^2	-	.9051
-.27428	10.32	S.E.E.	-	.06
-.00495	1.81	Mean	-	.16
.29924	27.38			
-.10938				
.15582	32.58	R^2	-	.9283
.01045	20.84	S.E.E.	-	.06
.22114	42.03	Mean	-	.04
.03516	3.93			
-.00022	8.62			

Ca^{++} Values

		Variable
Intercept	=	Constant
		Minimum Elev.
		Avg. Overland Slope
		Circularity Ratio
		RD/A
		MAC
Slopes	=	Constant
		Relief Ratio
		% Area Inceptisols
		Texture Ratio
		Avg. Avail. Capacity
		% Stream Length in Alluvium
Ionic Ratio	=	Constant
		Length of Overland Flow
		% Area Alluvium
		RD/A
		MAC
		% N. Aspect/% S. Aspect

Coefficient	F-Value		
68.88		R^2 -	.938
-.0056	5.65	S.E.E. -	4.37
-.013	13.19	Mean -	17.59
-27.11	3.64		
-24.53	26.15		
22.18	71.83		
-.21788		R^2 -	.8989
1.37409	48.08	S.E.E. -	.04
.00256	26.59	Mean -	.25
-.07799	13.80		
-.30517	11.38		
.00151	.25		
.85195		R^2 -	.8493
-.82026	10.32	S.E.E. -	.01
-.0312	5.55	Mean -	.51
.17707	11.14		
.03399	1.63		
-.00417	4.49		

Mg^{++} Values

		Variable
Intercept	=	Constant
		Median Elev.
		Total Channel Length
		Texture Ratio
		RD/A
		MAC
Slope	=	Constant
		Relief Ratio
		% Area Inceptisols
		Avg. Avail. Water Capacity
		RD/A
		% N. Aspect/% S. Aspect
Ionic Ratio	=	Constant
		Relief Ratio
		Texture Ratio
		Length of Overland Flow
		% Area Inceptisols
		% N. Aspect/% S. Aspect

Coefficient	F-Value			
22.44		R^2	-	.8918
-.0027	7.89	S.E.E.	-	1.08
.044	3.98	Mean	-	4.32
.69	3.32			
-4.66	15.19			
2.42	12.97			
-.55692		R^2	-	.9295
1.89672	68.73	S.E.E.	-	.04
.00256	21.36	Mean	-	.24
-.11571	5.66			
.12089	6.31			
-.00745	7.60			
-.02959		R^2	-	.8062
.26373	2.19	S.E.E.	-	.05
.02021	2.95	Mean	-	.23
.259	3.30			
.00104	5.93			
.00363	3.38			

SiO_2 Values

		Variable
Intercept	=	Constant
		Total Channel Length
		Drainage Density
		% Area in Alluvium
		% Stream Length in Inceptisols
Slope	=	Constant
		Relief Ratio
		Texture Ratio
		Form Factor
		% Area Inceptisols

Coefficient	F-Value		
60.97		R^2 -	.9696
.344	42.87	S.E.E. -	2.52
7.00	61.98	Mean -	29.03
-2.09	10.97		
-.413	29.93		
-.2761		R^2 -	.7929
.75003	14.23	S.E.E. -	.05
-.02445	1.90	Mean -	.16
-.28612	2.30		
.00202	12.48		

TDS W/O SiO_2 Values

		Variable
Intercept	=	Constant
		Mediam Elev.
		Total Channel Length
		Elongation Ratio
		RD/A
		MAC
Slope	=	Constant
		Relief Ratio
		Texture Ratio
		% Area Inceptisols
		Avg. Avail. Water Capacity
		RD/A

Coefficient	F-Value		
519.55		R^2 -	.9124
-.046	2.47	S.E.E.	-31.18
3.49	34.94	Mean	-131.96
-266.16	5.99		
-107.27	9.81		
92.54	18.96		
-.33726		R^2 -	.7915
1.28787	24.95	S.E.E. -	.06
-.03527	1.36	Mean -	.25
.00185	6.14		
-.18908	3.40		
.06845	1.01		

TDS WITH SiO_2 Values

		Variable
Intercept	=	Constant
		Minimum Elev.
		Total Channel Length
		Elongation Ratio
		RD/A
		MAC
Slope	=	Constant
		Relief Ratio
		Texture Ratio
		% Area Inceptisols
		Avg. Avail. Water Capacity
		% N. Aspect/% S. Aspect

Coefficient	F-Value		
239.83		R^2	- .9177
-.016	1.30	S.E.E.	- 31.30
3.47	38.62	Mean	- 161.40
-236.46	4.16		
-112.43	10.92		
108.70	43.85		
-.32448		R^2	- .8509
1.46221	36.62	S.E.E.	- .05
-.04309	3.83	Mean	- .23
.00242	16.35		
-.19551	6.31		
-.00378	1.85		

SPECIFIC CONDUCTANCE Values

		Variable	Coefficient
Intercept	=	Constant	630.61
		Median Elev.	-.057
		Total Channel Length	4.47
		Elongation Ratio	-317.89
		RD/A	-126.23
		MAC	115.62
Slope	=	Constant	-.42653
		Relief Ratio	1.62526
		Texture Ratio	-.03230
		% Area Inceptisols	.00259
		Avg. Avail. Water Capacity	-.14486
		% N. Aspect/% S. Aspect	-.00528

F-Value	
	R^2 - .9082
2.32	S.E.E. - 40.24
34.39	Mean - 158.85
5.13	
8.16	
17.77	
	R^2 - .8289
32.43	S.E.E. - .06
1.54	Mean - .24
13.43	
2.48	
2.58	